SCHOOL HYGIENE

ARTHUR NEWSHOLME M.D.
AND
WALTER C.C. PAKES, D.P.H.

LONDON · SCHOOL · OF · HYGIENE · AND · TROPICAL · MEDICINE ·

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SCHOOL HYGIENE

THE LAWS OF HEALTH
IN
RELATION TO SCHOOL LIFE

BY

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PREFACE.

THE former editions of *School Hygiene* have had a steady and increasing sale since its first issue in 1887. I have long felt, however, that the treatment of the subject was somewhat sketchy; and that in certain parts of the book the possession of a greater knowledge of hygiene and of the principles of preventive medicine underlying it was assumed than could reasonably be expected of teachers. Continued stress of other work has prevented me from re-writing the work on fuller and more explanatory lines; but having secured the co-operation of Mr. Walter Pakes, the task has been at last accomplished. I am chiefly responsible for the contents of Part I., and Mr. Pakes for the contents of Part II., but there has been a free inter-communication of suggestions in the preparation of the entire work. I have been fortunate in securing the aid of Dr. James Kerr, Medical Officer to the London School Board, in the preparation of the chapter on Eyesight.

The book in its new form is intended chiefly for teachers, school managers and others interested in School Hygiene. The chapters dealing with communicable diseases will, it is believed, be of great practical value to both medical officers of health and head teachers, although they are written in the main from the standpoint of the former. They are based on a long experience and careful study of the conditions necessary to be fulfilled in order that the efficiency and continuity of school attendance may not be injuriously affected by infectious diseases. These and other chapters, although written chiefly from the standpoint of the day school, will, it is believed, be valuable for teachers in boarding schools, with the additional information given on pages 168 to 171.

It may be urged that more minute explanation of elementary points in general hygiene has been given than is necessary in a work on the special hygiene of schools. Our experience has shown, however, that it is these points in particular which need explanation, and that in order to ensure the utility of the book we must not assume any previous technical knowledge on its subject-matter.

Any suggestions for improvement of future editions will be welcomed. In so large and well-worked a field as School Hygiene, it can scarcely be hoped that both omissions and inaccuracies have been entirely avoided ; but the statements of fact and opinion contained in this volume are based on our practical experience as medical officer of health and teachers of the subject. I am indebted to Dr. C. J. Thomas, Assistant Medical Officer to the London School Board, for revising proofs and for valuable suggestions in Chapter I.

ARTHUR NEWSHOLME.

TABLE OF CONTENTS.

PART I.—SCHOLARS.

CHAPTER PAGE

I. Physiology, Psychology and Ethics in Relation to Hygiene 3

II. Age and Sex in Relation to School Work . . 18

III. Excessive Mental Exercise 35

IV. The Care of Abnormal Children 46

V. The School Programme in Relation to Hygiene 52

VI. The Teacher's Health 68

VII. Eyesight in School Life 74

VIII. Physical Education 107

IX. Rest and Sleep 116

X. Children's Diet 120

XI. Children's Dress 124

XII. Baths and Bathing 127

XIII. School Accidents 129

XIV. Acute Infectious Diseases in School Life .. 137

XV. The Medical Inspection of Schools . . . 172

XVI. Communicable Diseases in School Life (*continued*) 178

PART II.—SCHOOLS.

XVII. Site and Surroundings 189

XVIII. Structure of the School Buildings . . . 196

XIX. Lighting of Schools 205

XX. The Necessity for Ventilation 212

XXI. Natural Ventilation 223

XXII. Warming of Schools 236

XXIII. Mechanical Ventilation 242

CHAPTER PAGE
XXIV. Water Supply 262
XXV. Disposal of Waste Matter 268
XXVI. School Furniture 281
XXVII. Cleansing and Disinfection of the School . 289

Appendix I. Board of Education Rules for Building Schools 295
Index 307
Appendix II. Board of Education Regulations as to Epidemic Grants 311

Snellen's Test Types.

LIST OF ILLUSTRATIONS.

FIG. PAGE

1. Chart of average stature, weight, etc., according to age and sex 32
2. Hand-balance 40
3. The typical facial aspect due to post-nasal adenoids . . 48
4. Vertical section of the eyeball 77
5. Physics 79
6. Diagram illustrating increasing amount of accommodation required with increasing nearness of object . . . 83
7. Percentage in each standard with defective visual acuity . 99
8. Percentage with defective visual acuity at different ages . 100
9. Section of hypermetropic eye 103
10. Section of myopic eye 104
11. Section through earth's crust showing strata and outcrop . 191
12. Showing flow of ground water and possible pollution . . 192
13. Showing effect of width of street on illumination of rooms . 194
14. Showing orientation in relation to lighting of school . . 195
15. Damp-proof course above level of ground 201
16. Damp-proof course below level of ground 201
17. Showing fireproof floor 202
18. Showing effect of bevelling windows on illumination . . 204
19. Showing how sun's rays may be cut off without preventing entry of diffused daylight 208
20. Prismatic glass for lighting a basement 209
21. Dry and wet bulb thermometers 219
22. Convection currents in an occupied room 225
23. Elevation and section of a double flue 231
24. Tobin's tube and outlet ventilator through ceiling . . 232
25. Sheringham's valve 233
26. Boyle's mica flap outlet ventilator 233
27. Hinckes-Bird window ventilator 234
28. Galton's ventilating stove 243

FIG.		PAGE
29.	George's Calorigen stove	244
30.	Bond's Euthermic stove	244
31. 32. 33.	Forms of ventilating radiators	247
34.	Condition of air of room with varying position of inlets and outlets in an artificially ventilated room	254
35.	Pasteur-Chamberland filter	266
36.	S-trap under wash-down water-closet	271
37.	Section of "wiped" joint before and after completion	272
38.	Valve-closet	273
39.	Long hopper water-closet	274
40.	Insanitary pan-closet	274
41.	Disconnecting chamber	275
42.	Earth closet	279
43.	Showing three relative positions of seat and desk	285

PART I.

SCHOLARS.

CHAPTER I.

PHYSIOLOGY, PSYCHOLOGY AND ETHICS IN RELATION TO HYGIENE.

THE future of a child is largely determined by its training and education. This is true not only for what is commonly but erroneously regarded as the main function of education, the instillation of knowledge and the training of the mind; but also for that ethical culture of the will which is set out by Rein, in his *Outlines of Pedagogy*, as the highest purpose of education. To understand the objects of education and to avoid possible dangers in connection with it, the teacher should be acquainted with the principles of physiology, psychology and hygiene in their application to child life.

The object being to secure *mens sana in corpore sano*, we must first consider the cerebral functions. The following is a brief outline of the **Anatomy and Physiology of the Nervous System** on which mental hygiene must be based.

Anatomy.—The nervous system of man is divided into two parts, *central and peripheral.*

The **central nervous system**, consisting of the brain and spinal cord, is encased in the skull and vertebral column; to the naked eye it consists of two kinds of material, *viz.*, grey matter and white matter. In the spinal cord the grey matter occupies a central position with the white matter surrounding it. In the brain the grey matter lies chiefly superficially, and constitutes the whole surface or *cortex* of the cerebral hemispheres, which form by far the greater portion of the human brain. In order to increase the surface of the cortical grey matter, the cerebral hemispheres are thrown into ridges and furrows, forming *convolutions* which have a fixed and definite arrangement.

The **peripheral nervous system** consists of *nerves* which present the appearance of white threads, and are distributed to the skin, muscles, glands and organs, forming a vast network by which each part of the body is linked up through the central nervous system to every other part. These peripheral nerves arise from the central nervous system in pairs. From the brain twelve pairs arise, and each of these twelve presents special and distinctive characters, the second pair, for instance, being distributed solely to the eyes, and the eighth pair solely to the ears. The spinal nerves, on the other hand, are all similar to one another in function. They spring from the spinal cord at regular intervals along its whole length ; each spinal nerve arises by two roots, an anterior root and a posterior root ; these two roots join and form the main trunk of the nerve which gives off branches. Each branch usually contains elements derived from both the anterior and the posterior root.

The foregoing is a general account of the nervous system as it appears to the naked eye. Microscopically all animal tissues are built up of cells. The cells of the nervous system are very specialised. Each **nerve cell** consists of a minute club-shaped particle of protoplasm, from one side of which short tufts or *dendrons* proceed, and from the other side one or more minute nerve fibres (*axon*), the whole being called a *neurone*. The fibrils of the axon probably pass through the cell body and originate in the dendrons. It has been discovered that the fibrils between the almost innumerable individual nerve cells of the cortex of the brain are not in permanent contact. There are between them minute gaps, possibly of not more than $\frac{1}{1000}$ of an inch (*synapses*), which cease to exist during the transmission of nerve currents. This throws important light on the processes of thought and on the mechanism of mental fatigue. As nerve currents pass through the brain by definite paths, there must be some mode of making and breaking contact between neighbouring nerve cells. The exact nature of this mechanism is unknown. It may be that the dendrons of the nerve cells lengthen to make contact under the stimulus.

The **grey matter** of the brain and spinal cord consists chiefly of aggregations of such cells and fibrils. Every nerve fibre is a prolongation of a nerve cell and is dependent upon the cell for its nourishment. The **white matter** consists solely of fibres, each surrounded by a *medullated sheath*, consisting of a fatty, insulating material which gives rise to the white appearance. The white matter, therefore, since it contains no nerve cells, simply serves to link up the various parts of the nervous system together.

The **peripheral nerves** consist of great numbers of nerve fibres, for the most part medullated, each nerve fibre being a prolongation of a cell of the central nervous system ; the nerves branch and branch again until each nerve fibre terminates in an *end organ* in the muscle, skin, gland or other structure to which it is distributed.

Physiology.—When a peripheral nerve is divided the organ to which it is distributed is deprived of its connection with the central nervous system. Occasionally a nerve is found which supplies skin alone. When such a nerve is severed sensation is lost in the part of the skin to which it is supplied, and such a nerve is called a purely *sensory nerve*. Occasionally a nerve supplies a muscle alone, and its division causes paralysis of the muscle ; such a nerve is termed a purely *motor nerve*. Most of the peripheral nerves are *mixed*, *i.e.*, contain both sensory and motor fibres.

All the sensory fibres of a spinal nerve enter the spinal cord by the *posterior* or *sensory root*, all the motor fibres pass out from the cord by the *anterior* or *motor root*. Thus, if the anterior root of a spinal nerve is alone severed paralysis occurs in all the muscles supplied by the nerve, while sensation in the tracts of skin to which the nerve is distributed remains unimpaired. The reverse effect is produced by division of the posterior root alone.

Nerve fibres cannot originate impulses. They only transmit them ; they bear the same relation to nerve centres as telegraph wires to the batteries which generate the current. The difference between motor and sensory fibres is in the nature of the peripheral and central connections of the nerves rather than in the fibres themselves.

The central nervous system consists, as we have seen, of grey and white material. The white material consists of medullated fibres which merely act as conducting agents, joining together various portions of the grey matter. The grey matter contains millions of nerve cells, which are aggregated together into centres. If the spinal cord be completely severed in the middle of the back sensation and voluntary motion are lost below this part of the body, because the conducting paths to and from the brain are destroyed. Nevertheless, if under such circumstances the foot is pricked, movements occur known as **reflex movements.** Such unconscious movements play a large and essential part in the economy of life. The spinal cord is the site *par excellence* of reflex centres.

The **cortex** of the brain consists of cells aggregated together to form the higher sensory and motor centres. The main sensory cortical centres correspond to the senses of touch, sight, hearing, smell and taste. Each of these centres occupies a special and separate convolution or series of convolutions. Stimuli from the external world are received by the sensory end organs, and are there converted into nervous impulses. For example, contact of a foreign body with the skin is converted by the endings of the sensory nerves into a centripetal impulse which passes up to the spinal cord by the posterior root, and is then carried by relays of cells with their axons to the touch centre of the cortex; here it becomes converted into the *sensation* of touch. Similarly rays of light falling on the retina, which is the end organ of the optic nerve, set up nervous impulses which travel to the cortical centre for sight, where the *ego* becomes conscious of the sensation of light, and the physical becomes psychical. In the cortical motor centres originate those impulses which result in voluntary motion. Voluntary acts are usually preceded by conscious reception of preceding sensations. Other cortical centres will be considered when the faculty of speech is dealt with (p. 11). Besides voluntary acts there are semi-unconscious and unconscious acts in which only the centres of the lower part of the brain are brought into operation.

What are known as **automatic movements** occur independently of any immediate disturbing influence from without. Such are the movements of respiration which are controlled by a centre situated in the medulla oblongata—the portion of the brain which is in anatomical connection with the spinal cord, and bears the greatest resemblance to it. Complex acts such as walking and writing require to be learnt, in the first instance, slowly and with great pains under conscious control. During the process of education these are delegated to the control of lower centres and become in time automatic. Slovenly and clumsy acts if allowed to be repeated become fixed in the nervous system as such, and when thus groups of cells have become associated together to represent these acts it is too late to correct the fault. It is while new accomplishments are being learned, and still being guided by conscious effort, that constant and assiduous care on the part of the teacher must obtain. Prevention is always possible, cure almost never. Memory of all kinds depends on the fact that once a pathway in the nervous system is traversed the easier is it for an impulse to travel along it again. The oftener the pathway is used the more fixed it becomes and the greater likelihood there is of a nervous impulse tending to travel by it. Thus are formed habits whether good or bad. Habit is the memory of the *lower* centres. "The great thing, then, in all education, is to make our nervous system our ally instead of our enemy. It is to fund and capitalise our acquisitions, and live at ease upon the interest of the fund. For this we must make automatic and habitual, as early as possible, as many useful actions as we can, and guard against the growing into ways that are likely to be disadvantageous to us, as we should guard against the plague."—(William James.)

Nutrition of the Brain.—Whatever view be taken as to the exact relationship between mind and brain, it is agreed that the brain is the instrument necessary for all mental operations. The nutrition of the brain depends upon its having an abundant supply of blood of good quality. Thus any constitutional weakness associated with feeble circulation, or anæmia (impoverished blood), or the circulation in the brain of blood rendered impure by contaminated air, will impede and embarrass the mental functions. Deficient food or indigestion, like an impure atmosphere, causes the circulation in the brain of impoverished or poisoned blood, leading to listlessness, apathy, headache and other nervous symptoms.

Mental activity is accompanied by an increased flow of blood to the brain, and with increased flow of nutritive material the brain grows. Hence, within reasonable limits, mental activity produces increased mental power.

Development of the Nerve Cells.—The brain can scarcely be considered as a single organ, but rather as *a collection of organs*, which, although intimately united, are capable in some measure of independent action. Different convolutions of the brain, as we have seen, have special functions, and disproportionate development of any one part may be produced by excessive mental activity in a particular direction. It is important therefore that there should be early and systematic mental exercise directed to the uniform development of all parts of the brain. Specialisation should come later.

Studies requiring observation, memory, or reasoning, bring into action different parts of the brain, and each requires careful and balanced attention. The utility of a brain depends largely upon its readiness of response to stimuli. Corresponding to each thought there is a nerve current in a particular part of the brain. Nerve currents travel most easily in the pathways of least resistance; that is, where currents have repeatedly passed. Hence, careful and persevering attention to the formation of good habitudes of thought will strengthen individual character. In this way a wise teacher may help to counteract evil hereditary tendencies or newly acquired habits of an objectionable character, and thus aid in the formation of a strong and evenly balanced mind.

The four chief means for the development of the nerve cells are :—

1. Afferent impulses reaching the brain from the different sensory organs ;
2. Efferent impulses passing from the brain to initiate muscular acts or to cause their repetition ;
3. Functions of association between the two above, as, for instance, when a lesson dictated by a teacher is being written down. Here the afferent impulses are received by the ear ; the efferent are transmitted to the muscles employed in writing.

4. Co-ordination of efferent impulses to produce harmonious action of a complex character. Thus, in reading or writing the necessary co-ordination of the muscular movements involved is chiefly effected by the nerve centres at the base of the brain and in the cerebellum.

The **education of the senses** must precede the education of the mind. In the order of time it comes first, the memory coming next, then the understanding, and lastly the judgment being developed. When the education of the senses is neglected, all subsequent education has a haziness about it which is almost irremediable. The Kindergarten system, where its principles are properly understood and applied, cultivates the senses and power of observation, comparison, proportion and construction in early life, and has therefore a high educational value.

The different sensations are received in different parts of the brain. Hence, the cultivation of one sensory organ (or rather of the corresponding part of the brain) may be encouraged to the neglect of other senses. Thus a boy with an excellent sense of touch, or an accurate perception of weight and resistance, may have no liking for music.

Each sense requires special cultivation, and becomes skilled in proportion to the education received. It has been well said by Dr. Clarke: "If a single organ is wanting, or a single function not performed, just so much less brain development results". It is also unhappily true that the imperfect performance of any one mental function reacts injuriously on others. There is much truth in the poetical statement—

Break but one
Of a thousand keys, and the paining jar
Through all will run.—(Whittier.)

Especial mention must here be made of the **Muscular Sense**, inasmuch as too little attention is often paid to the value of its orderly training. It is this sense which makes us aware of our own movements and postures; upon it depend the smooth and orderly succession of contractions on the part of muscles which result in the unerring and unhesitating performance of complicated purposive movements. The object of physical exercise should be as much the training of this sense as the development of muscular force.

When the delicate musculature of the eyes and larynx is borne in mind the vast importance of this sense becomes more apparent. By it the eyes are educated to judge the distance, size and relation of objects, and so to build up an estimate of external space. In the training of the voice, also, the muscular sense is that chiefly concerned, and the production of a note of accurate pitch is an exquisite example of its power.

The **Speech Faculty.**—The intellectual life of man is closely associated with his power of speech; with the growth of this faculty definite centres become organised in the brain; these speech centres are mainly four, *viz.*, the *auditory word centre*, the *visual word centre*, the *motor speech centre* and the *writing centre*, which are all situated on the left side of the brain. In the auditory word centre are stored up the memories of words *heard*, in the visual word centre are stored up memories of words *seen;* the motor speech centre is that part of the brain in which originate the impulses to utter words; and similarly the writing centre originates impulses which result in written words. The auditory word centre and the visual word centre together form the receptive side of the speech faculty; the motor word centre and the writing centre together form the expressive side. In correspondence with this division, the two components of the receptive speech mechanism are placed near one another, but at a distance from the two components of the expressive side of speech, which are similarly in close proximity to each other. All these centres are linked up by countless nerve fibres. In the process of silent thought, words are revived in the auditory word centre and usually also simultaneously in the visual word centre. The motor speech centre is " educated by the auditory word centre and depends upon it for its incitation " ; the visual word centre, although it educates and controls the writing centre, is also dependent to a large degree upon the auditory word centre. In addition to these purely speech centres there are other closely associated centres ; a *visual centre* near the visual speech centre wherein are stored the memories of the appearances of objects, an *auditory centre* wherein are stored the memories of sounds other than spoken words. To enjoy intellectual life to the utmost, to develop it to the full, all these centres should be fully educated. People may be divided into two main classes, those in whom the auditory centres are strongly developed to the detriment of the visual centres—these people are sometimes called " strong auditives," and those in whom both auditory and visual centres are balanced. A person in whom the visual centres are too strongly developed to the detriment of the auditory is a rarity and would be termed a " strong visual ". Uneducated people in our country usually have their auditory speech centres too strongly developed, hence it is that conversation among the uncultured classes is limited almost entirely to accounts of the observations of others gathered from speech ; their talk is interlarded with the constant repetition of " he says " and " she says " and " they said," and their intellectual life limited almost entirely to mere gossip. With this must be contrasted the conversation of the educated and cultured, which abounds in description of scenery, of pictures and quotations from books ; memories dependent upon the visual centres, derived from original observation and gathered from others.

The mind, we have seen, is largely dependent upon sensory impressions for its education and development. The states of action of the mind are feeling, ideation and volition ; and these are all dependent, directly or indirectly, upon impressions received from without, either at the time or stored up by the powers of memory. The accuracy of the memory depends upon the vividness of the original nerve currents producing the impression. Thus the impression may be deepened by appealing to more than one sense, as well as by repetition of a particular impression. This principle is important in intellectual training. Experimental teaching is more easily remembered than merely verbal teaching. The most impressive teaching, because it arouses most associations, is the experimental. Froebel's maxim "Learn by doing" embodies a great truth, especially as it brings the motor and the intellectual parts of the brain into close intercommunication. The influence of muscular exercise on brain development will be further discussed on page 109.

Memory, as we have seen, is dependent upon vividness of impressions or upon the repetition of less vivid impressions. According to Comenius, "Repetitio memoriæ pater et mater est".

Conscious memory comes under two categories. In one the exact words, of a poem, for instance, are committed to memory ; in the other the gist of a statement of fact or of an argument is reproduced. Both these powers are valuable, but the latter most valuable. A common deficiency in teaching is that a given subject having been made perfectly clear to the pupil, he soon forgets it, because no opportunity is given him to reproduce what he perfectly understands ; and by thus repeating the impression fix it on his memory. An essential part of education is to train children to reproduce in their own words what they have learnt. By this means much of the strain otherwise liable to be produced by examination work may be avoided.

Besides the memory based on impressions which have come within the range of active consciousness, there is a large sphere of **sub-conscious memory.** Many sensations make their impress on the brain and are stored up in it, without ever reaching the region of consciousness. These impressions we cannot afford to neglect in educating a child. He is always learning, wittingly or unwittingly; and it is essential therefore that the impressions sub-consciously received should not be in any sense antagonistic to conscious impressions. These considerations emphasise the importance of the child's environment both at home and school. Refined conditions of life, beautiful pictures and other evidences of culture react on the intellectual development of the child just as much as does an example, on the part of parents and domestics as well as of teacher, of unswerving integrity of character and self-control. The sub-conscious education of the senses can be improved by training, as by the child being set to recount or describe the particulars of a visit to a museum or any special expedition (see page 59).

The application of the preceding general considerations to the training of young children is admirably summarised in the following instructions issued to H.M. Inspectors by the Board of Education:—[1]

> Two leading principles should be regarded as a sound basis for the education of early childhood:—
>
> 1. The recognition of the child's spontaneous activity, and the stimulation of this activity in certain well-defined directions by the teachers.
> 2. The harmonious and complete development of the whole of a child's faculties. The teacher should pay especial regard to the *love of movement*, which can alone secure healthy physical conditions; to the observant use of the organs of sense,

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[1] *Instructions to H.M. Inspectors.* Appendix VIII., *Instruction of Infants*, 1901.

especially those of *sight and touch;* and to that eager desire of *questioning* which intelligent children exhibit. All these should be encouraged under due limitations, and should be developed simultaneously, so that each stage of development may be complete in itself.

It has been strongly urged that sufficient attention has not been paid in the past to these principles; indeed, it is often found that the Kindergarten Occupations are treated as mere toys, or amusing pastimes, because they are attractive for children, and the intellectual character of the "Gifts of Froebel" is disregarded, whereas the main object of these lessons is to stimulate intelligent individual effort.

The attention of teachers should be directed to the chief consideration which underlies true methods of infant teaching, *viz.*, the *association of one lesson with another through some one leading idea or ideas.* The reading lessons, occupations and object lessons may all be usefully combined for one purpose, *e.g.*, if the teacher wishes to impress on her class some knowledge of a domestic animal, she may usefully combine the object lesson for general study of its structure; the reading lesson for a knowledge of its habits and character; some occupation, such as pricking the outline, to impress an exact knowledge of its form; a song or simple story bearing on its association with human life; so that familiarity with animals, especially with domestic animals, and a kind treatment of them, may be fostered.

On the other hand, teachers should be cautioned against the mere repetition of the same exercises and lessons; the progressive character of the whole scheme of instruction should be constantly kept in view: and each exercise should lead up to something beyond itself.

Pictures and flowers have been wisely introduced of late in greater abundance into infant schools and have added much to their cheerfulness and attractiveness. They should be frequently taken down into the class, and made the subject of conversation. It is not enough that the children should be taught to observe these things and to answer questions upon them. They should be encouraged in every way to give expression in their own words to what they know, what they want to know, and what they think.

It will he found that the Elementary Subjects when taught on right methods can be treated with great variety; Reading becomes a Kindergarten lesson through pictures and word building; Writing becomes a variety of Kindergarten drawing; elementary exercises in Number are associated with many of the Kindergarten occupations.

It is the experience of many good teachers that by the adoption of such methods it is found to be unnecessary before the sixth year is passed to employ books for reading, except occasionally for a change of occupation, or perform any exercise in Writing except the elements of letters, or to do any formal Arithmetic work on slates.

It may reasonably be hoped that the observance of these suggestions will materially improve the work of the younger children in infant schools and classes, by relieving the teacher from that useless subdivision in the elementary subjects, which has been hitherto generally employed, and by rendering the instruction less formal, but more varied and attractive.

No consideration of the physiological aspect of education would be complete which ignored its ethical bearings. A high standard of mental culture may be associated with defective morality. If this is to be prevented, moral strength of character must be cultivated. Kant and Herbart claim that the will is the proper object of all ethical valuation, from which it follows that the ethical culture of the will is the highest purpose of education.[1] Two means for advancing the pupil toward this supreme end of education are described by Rein, *training* and *instruction*. Instruction deals with something distinct from either teacher or pupil. It is the acquisition of information. Training deals directly with the pupil. By training and example the pupil is taught to obey, to speak the truth, to be moderate in his enjoyments, and to practise self-control and self-denial. The importance of such moral teaching both in securing the highest standard of school work and in securing the best health is immense. In the prevention of school vice it exerts a most beneficial influence (see page 51). The strongest motives actuating the will arise from love and desire, and from the force of example. In all these respects a teacher of high moral tone may effect great good. Plato said, "Virtue can only be taught by virtue, in that the living exemplification of it awakens love and the desire to emulate".

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[1] *Outlines of Pedagogics*, by Prof. W. Rein (translated by Van Liew. Sonnenschein, 1893.)

In this higher view of education instruction necessarily occupies a secondary position ; with the exception of religious instruction, which, in virtue of its character, can exert an influence upon the will of the pupil. The teacher is often regarded merely as an instructor ; family life being supposed to supply the training of education. The true teacher, who is most successful in his work, is, however, educator as well as instructor. Instruction generally may be made educative if it goes beyond the mere supply of a fund of ideas. When these ideas penetrate into the sphere of the disposition, when, in other words, interest is excited, volition becomes involved, and instruction then attains an ethical value. Success in teaching depends in a large measure on so teaching and so regulating instruction that interest may be kept up, and the developing personality of the pupil progressively improved. The mere piling up of the material of instruction, apart from the harmonious correlation of different subjects and its due use in training the pupil in the control of his volition, does not constitute complete education.

CHAPTER II.

AGE AND SEX IN RELATION TO SCHOOL WORK.

AGE has a most important bearing on the character, amount and distribution of the work to be given to children. During the period of *childhood*, including up to the end of the seventh year, more rapid changes are taking place than at any subsequent period of life. At seven years old a child weighs about six times as much as at birth, and has more than half the stature, and one-third of the weight of an adult, while its brain at the same age has attained nearly its full size. This does not, of course, imply that it is fully developed. Practically no book work should be attempted during this period. Education is not confined to schools. From the first moment of life education in the best sense commences, and makes rapid strides. The senses become trained, and the powers of observation are perhaps keener than at any subsequent period, while the mind is becoming stored with impressions which form the groundwork of subsequent mental life.

Capacity for Training.—In the simplest discussion of the training of a growing child, the unit for consideration is the nerve cell, which comprises the cell body and its short processes the dendrons, its long process the nerve, the whole structure being called a neurone (page 4). All actions are the result of functioning of neurones, which again result from some stimulus reaching them either directly from sense organs or indirectly through other neurones (see also page 5).

The individual cell, which at first is incapable of functioning, with growth develops so that it can produce certain effects in a crude way, not reacting promptly to a simple stimulus, but along with numerous other neurones in its neighbourhood as the result of some strong stimulus which also influences these to a greater or less extent. Irregular badly controlled and inco-ordinate movements result with consequent rapid exhaustion; the cell being as yet too immature for economical and effective education.

At a later stage of growth development is much aided by occasional exercise, and the neurone is capable of exact functioning; then attaining the condition for most effective education, but still undergoing comparatively rapid exhaustion.

With full growth the neurone should be capable of long continued and exact work, and in this stage is mature. It has now passed beyond the need or possibility of further education, and to work it with this view is wasted effort.

The neurone best suited for educational development should be frequently but not too continuously worked, for when benefiting educationally it is undergoing fatigue. Even a very immature cell can be educated, but it is at the expense of wasteful training and rapid exhaustion. There is no royal road to learning, and efficient education always implies the exertion of effort and the production of fatigue, but should never be exhausting.

Order of Development of Nerve Cells.—The cell groups pass through these stages at different times. The first neurones to attain maturity represent the earliest acquired reactions, which are those oldest in the history of the race, reflexes inherited from time immemorial; next the largest and coarsest movements and crude sensations, which are most permanent, soon attain maturity, and are least amenable to education. The finer muscular movements of the smaller muscles, lastly of the fingers, and the finer indications of the special senses come later, about the middle of school life, and are most capable of training by educational methods in the first half of school life. The complex co-ordinations which are practised during school life become as mature actions almost unconscious reflexes, *e.g.*, the mechanical part of reading and writing, the pose of the head and carriage of the body. The complex interpretation and intellectual appreciation of sights and sounds are very late acquirements, and pass into the fully educated condition in the last half of school life, and during the next ten years are still capable of much educational development, and, so far as relates to the highest functions, for many subsequent years.

In the last half of school life, in the widest sense, the higher intellectual co-ordinations of sensations and movements are being grouped into the most complex ideals and memories.

To attain this end the highest intellectual centres require to be educated by hard work with conscious mental effort.

At the age of three the child may be taken to have learned to stand and walk. It may at this age still require to have these co-ordinations trained. Coarse muscular exercise in moderate amount and frequently repeated daily for short times, as marching, hopping, jumping, standing first on one leg then on the other, and so forth, are useful forms of training at this time of life. The movements of the eyes in watching distant objects should be chiefly used, and until five years of age only the coarse muscle movements, such as are concerned in running, jumping and swimming, and those of the shoulder girdle and arms should be definitely worked, and only coarse eye work attempted.

Working with Small Objects in Infant Schools.—If children in the infant school are allowed to work with small objects they cannot possibly be prevented from forming the habit of working at too near a distance;

and if they are allowed to do fine work it is impossible for teachers to make them sit up from their work. Such work also implies fine finger work, and the nerve groupings which are concerned with finger work are so immature that children under six can only do it inco-ordinately and badly and with immense strain and rapid exhaustion (see also page 89).

Children at this stage, that is, four to six or seven years of age, should never be allowed near eye work or finger work ; for such children the only graphic forms permissible are chalk drawing and writing on the blackboard, while work with sand trays, big bricks or sticks, big beads or shells, should entirely replace any finer work. The Kindergarten employment known as "embossing," whereby the area enclosed by an outline on a piece of paper laid on a pad of felt is pricked over by a needle in a holder, is one of the severest strains ever imposed on children. It is fortunately dropping out of use now, but sewing with needle and thread is still allowed.

Nerve strain in practice can be seen at any time in an infant school if a class be carefully observed, without interruption from the teacher. Although Kindergarten embossing is the severest strain, sewing will be quite sufficient to point the way for observation of this kind.

A class of girls under seven set to sew may be placed in a correct attitude, sitting upright with the light falling from behind and from the left. They will maintain this attitude for a period to be measured by seconds rather than minutes. Sewing involves fine eye work ; it should be done intuitively almost without the eye, but that is after education ; by the learning child who is often incapable of threading the needle, owing to its normal condition of long-sightedness (page 82), the sewing is done by watching the needle point, a comparatively small object, on a background which does not improve its visibility.

For reasons given on page 20 the child brings its eyes and the needle within 4 or 5 inches distance of each other, and no teacher can be expected to prevent this in the infant school. But the material is held in the hands, and the mere holding up of the hands long continued is a strain no child can maintain; it therefore crouches so that the elbows can come either on knees or abdomen. The work of managing the needle is fine muscle work for the fingers, and these muscle centres in the brain, being comparatively immature, can only be kept at work by excessive working strain. This excess of effort overflows to adjoining brain centres, and causes through them the continual twisting of body and neck, and grimaces which young children subjected to this unsuitable task will occasionally be seen to make, some of course being much worse than others. These "**nerve signs**" tell of exhaustion and wasteful expenditure of nerve energy (see also page 40). Children showing them are all suffering temporarily from the strain of over-pressure, for over-pressure is less likely to be quantitative than qualitative. For such children, therefore, sewing involves educational over-pressure.

The **Lower Limit of Age for School Attendance.**—A study of the preceding physiological considerations will indicate the absurdity of the attendance at school and teaching of children under seven years of age under the conditions commonly present in infant schools. The question is, however, one of such great importance that we propose to give it somewhat fuller consideration.[1] The official limits of school attendance at public elementary schools in England are stated in the Day School Code of 1901 as follows:—

> *No attendance is, as a rule, recognised for any scholar under three years of age*, or for any scholar who has been under instruction for

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[1] See a paper on "The Lower Limit of Age for School Attendance," by A. Newsholme, *Public Health*, July, 1902.

more than one year in the three elementary subjects in Standard VII., and is upwards of fourteen years of age, or for any scholar while habitually employed as a monitor.

In practice this means that[1] only 3,253 children under three were on the school registers as compared with 5,702,422 over this age. At ages three to four the number on the school registers was 205,744, or 3·6 per cent. of the number at all ages, at four to five years of age the percentage of the total number at all ages was 7·3, at five to six it was 10·2 per cent., at six to seven 11 per cent., at seven to eight 11·1 per cent., at eight to nine 11·0 per cent., at nine to ten 10·8 per cent., at ten to eleven 10·7 per cent., at eleven to twelve 10·3 per cent., at twelve to thirteen 9·2 per cent., at thirteen to fourteen 3·8 per cent., and at fourteen and over ·95 per cent. Thus 10·9 per cent. of the total scholars at all ages were under five years of age when compulsion to attend school comes into operation, 10·2 per cent. were between five and six years of age, while only 4·7 per cent. were over thirteen years of age. The chief reason for the large attendance of children under five years of age is in our opinion not strictly educational, but the desire on the part of poor mothers to be temporarily freed from the charge of their children, and the corresponding desire on the part of school authorities to prevent older girls being kept away from school to help in nursing children under five. Have any good results been obtained by the attendance at school of children under five?

The standard required by the Board of Education is indicated by the following extract from par. 7 of the *Revised Instructions Issued to H.M. Inspectors and Applicable to the Code of 1900*:—

"A scholar of ordinary capacity, who has entered school at five years of age, or soon after, may reasonably be expected to be fit for promotion to Standard II. at seven years of age." This implies that he will then be able (1) to read a short passage from a book not confined to words of one syllable; (2) to copy in manuscript characters a line of print, commencing with a capital letter; (3) to add and subtract figures up to 1,000, the number of lines in addition not to exceed five, and to know the multiplication table up to 6 times 12.

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[1] Report of Board of Education, 1900-1, vol. ii., p. 368.

In Appendix VIII. of the Instructions to Inspectors, immediately following the sentence already quoted, occur the following words:—

> The improvement also shown in passing the standards at an earlier age than formerly gives to infant schools greater liberty and leisure in developing natural methods of education.

Some further idea of the views of the Board of Education on the education of children under five, and between five and seven, may be gathered from another part of Appendix VIII. The following is given as a list of

A.—What children between the ages of five and seven can do:—

- Games with music.
- Games without music (guessing games, etc.; taking messages).
- Picture lessons.
- Object lessons.
- Story lessons, *e.g.*, stories from history; Grimm's Household Tales.
- Recitations.
- Paper folding.
- Mosaic with coloured paper; use of gum.
- Drawing. Brush drawing.
- Plaiting paper.
- Ruling simple geometrical forms.
- Measuring length. Estimating length.
- Weighing. Estimating weight.
- Setting a table (carrying a glass of water without spilling it. Moving cups without breaking them.)
- Modelling in clay.
- Basket work.
- Cutting out patterns and shapes with scissors.
- Word-building.
- Number pictures, with cubes, beads, etc.

B.—What children between three and five years of age can do :—

- Games with music.
- Games without music (guessing games, etc.).
- Recitations—nursery rhymes, etc.
- Picture lessons (learning to answer in complete sentences as to what they can see in a picture).
- Paper folding.
- Mosaic with coloured tablets.
- Drawing.
- Matching colours (picking out the same shades of wool from a heap of remnants).
- Plaiting paper.
- Working patterns with needle and worsted.
- Threading beads in twos, threes, etc.
- Arranging shells in twos, threes, etc.
- Arranging " pictures of number " with cubes.
- Word-building.

In another part of the same Appendix it is stated to be

> The experience of many good teachers that by the adoption of such methods[1] it is found to be unnecessary before the sixth year is passed to employ books for Reading, except occasionally for a change of occupation, or perform any exercise in Writing, except the elements of letters, or to do any formal Arithmetic work on slates.

This ideal is in accordance with the general principles laid down in the preceding pages, but unfortunately the teaching of reading, writing and arithmetic by means of books is still common before the sixth year of life. Even if it were otherwise, a large portion of the occupations officially specified as suitable for children from three to seven (p. 24) must be strongly condemned in view of the considerations given on pp. 19 to 22 and 84. Near-sightedness is much more common among young children made to attempt accurate manipulations on a small scale involving focussing the eyes on near objects than among children who do not encounter the eye-strain of such school work until they are seven years of age.

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[1] *I.e.*, treating reading as a Kindergarten lesson through pictures and word-building, writing as a variety of Kindergarten drawing, etc.

The **attendance** at public elementary schools **of children under five** is in fact unassociated with any material educational advantages, and it entails, on the other hand, very serious disadvantages.

1. It constitutes a waste of both national and local funds, owing to the provision of school accommodation, teachers and appliances, which is necessitated. In the paper already mentioned one of us has calculated that on the moderate estimate that each child under five years of age in average attendance costs at least £2 per annum, the average attendance at infant schools of such children being known to be about 72 per cent. of the number on the register of these schools, it follows that over £900,000 is spent annually on the attendance at school of children, who, we contend, obtain no scholastic advantage by such attendance.

2. Such premature school attendance tends to "force" functions of the brain which should only come into activity at a later age (see preceding pages), and so favours mental deterioration. It also greatly increases the liability to near-sightedness and general ill-health. It is argued that apart from the excessive incidence of infectious diseases to be next considered, the children of the poor are more favourably placed in a large warm schoolroom than in their homes. In naturally ventilated schools this is the exact opposite of the truth. Even in mechanically ventilated schools sixty to seventy infants cannot be collected in a class-room without some fouling of air. The atmosphere of even the bedrooms of the vast majority of the poor is less polluted than that of the vast majority of schools.[1]

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[1] Thus Messrs. Carnelley, Haldane and Anderson in a valuable series of observations (*Proc. Roy. Soc.*, vol. 178 (1887), pp. 61-111) obtained the following results:—

[*Footnote continued on next page.*]

3. A large loss of human life is caused by the aggregation of classes of fifty to seventy children at ages when they are more prone to be attacked by infectious diseases, and when these attacks are more fatal than at any later ages. In regard to these diseases the evils of aggregation increase factorially—in geometrical rather than in arithmetical progression. Were the number of children aged two to five in each infant class ten instead of sixty, and were these ten not to be intermingled with other tens throughout the day, much of the force would be taken out of this contention. That this is so is shown by the comparative rarity with which infectious diseases are in our experience spread in crêches.

If the community gained greatly in educational efficiency by the school attendance of children under five years of age, a considerable loss of life from this cause would be justifiable; and the range of investigation might then be regarded as limited to the investigation and execution of measures calculated to minimise this loss. No great educational gain for the children themselves is, however, definitely claimed for such school attendance. On the other hand, as shown on pp. 167 and 168, the proclivity to attacks by some and probably by all the chief infectious diseases

Carbonic Acid in 10,000 *volumes.*

Of 29 one-roomed houses	examined	14	contained above	and 15	below	10 vols.
,, 13 two- ,,	,, ,,	5	,, ,,	,, 7	,,	,, ,,
,, 18 four (or more) ,,	,,	1	,, ,,	,, 17	,,	,, ,,
,, 42 naturally ventilated schools	exd.	38	,, ,,	,, 4	,,	,, ,,
,, 26 mechanically ,,	,, ,,	21	,, ,,	,, 5	,,	,, ,,
,, 42 naturally ,,	,, ,,	31	,, ,,	,, 11	,,	13 ,,
,, 26 mechanically ,,	,, ,,	9	,, ,,	,, 17	,,	,, ,,
,, 42 naturally ,,	,, ,,	29	,, ,,	,, 13	,,	14 ,,
,, 26 mechanically ,,	,, ,,	4	,, ,,	,, 22	,,	,, ,,

The samples of air from dwelling houses were taken from bedrooms between 12.30 and 4.30 in the night.

and the fatality when attacked is greater at ages below than above five. It is therefore clear that great importance attaches to the postponement of attacks of the acute infectious diseases. Is postponement of school attendance until the end of the fifth year of life likely to have a material influence in producing this effect? The official experience of one of us is that the attendance at school of children under five is a chief cause of the most fatal attacks of the chief infectious diseases, and that the most rapid means for subjugating these diseases is prompt school closure (p. 157). In actual practice school closure is effective, especially for diphtheria. Nor on consideration is this surprising. Contact between well and sick out of doors is less intimate and less protracted than indoors. Contact in neighbours' houses is limited to a few possible sources of infection; in a classroom containing the sixty children allowed by the Education Code, the contact is with a large number of possible sources of infection. To use a homely illustration, it is the difference between "retail" and "wholesale" infection. Similar remarks apply to measles and whooping cough, and to a less extent to scarlet fever (see p. 165).

For the above reasons, we strongly advocate the exclusion of children from elementary schools until they have completed their fifth year, and the provision, if mothers cannot attend all day to their own children, of a co-operative system of crêches in individual streets. These would present the important advantage from the standpoint of public health that the risks of the importation of "foreign" infection from other streets or other parts of a town are reduced to a minimum.

The question of duration of lessons in accordance with age is discussed on page 53.

Height and Weight of Children.—Much valuable information as to whether school work is overtaxing a child can be obtained by periodical weighings. It would be well if every parent would at intervals of three months or even oftener have his children weighed and measured, keeping a record of the result.

Such information is easily obtained and would be of immense value in warning as to the insidious onset of disease, or a too rapid increase in stature. It is well known that when a boy is growing very rapidly his powers of mental application become greatly diminished. He is dull and apathetic, and perhaps lays himself open to undeserved censure, which might have been averted had the parent informed the teacher of the rapid growth and consequent necessity for diminution of work. Any increase in size beyond 2 to 3 inches a year involving undue strain on the system, or any sudden stoppage of growth (indicating perhaps the onset of consumption or other diseases, especially if accompanied by diminished weight), should excite apprehension and lead to medical supervision.

Stoppage of growth or of increase in weight might be due to (1) insufficient food or clothing, the food being required to keep up the temperature of the body and no surplus being left for purposes of growth ; or (2) excessive expenditure of energy in mental work ; or (3) the onset of some disease. In all cases it requires careful attention even when no other indications of disorder are present.

Observations on a large scale on children show that the most rapid growth in both height and weight occurs (*a*) in the first year of life, (*b*) in the thirteenth and three or four successive years of life. This is shown in the following table relating to boys, the first three columns in which give the figures for each year of life, the next three the annual increment, and the last three the ratio of each year's increment to the total of the preceding year.[1]

The three last columns show that the proportional increase (to the total weight, height or girth of the body) as well as the actual increase is greatest in the early years of life.

Year of Age.	Successive Totals of			Increment in each Year.			Ratio of Increment to Last Year's Total.		
	Height. A.	Weight. B.	Chest Girth. C.	Height.	Weight.	Chest Girth.	Height.	Weight.	Chest Girth.
	Inches.	Lbs.	Inches.						
Birth	19·7	7·5	13·2						
1	28·5	15·0	17·2	8·8	7·5	4·0	·45	1·00	·30
2	31·6	24·75	17·5	3·1	9·75	0·3	·11	·65	·27
3	35	28·80	18·6	**3·4**	4·05	1·1	·10	·16	·06
4	38·5	35·00	19·7	2·5	**6·20**	1·1	·07	**·21**	·05
5	41·3	40·49	21·2	2·8	5·49	**1·5**	·07	·16	**·07**
6	43·8	44·79	21·6	2·5	4·30	0·4	·06	·11	·01
7	45·8	49·39	22·2	2·0	4·60	0·6	·04	·10	·02
8	47·4	54·41	22·6	1·6	5·02	0·4	·03	·10	·01
9	49·7	59·82	23·2	**2·3**	5·41	0·6	·05	·10	·02
10	51·7	66·40	23·7	2·0	**6·58**	0·5	·05	**·11**	·03
11	53·5	71·09	24·3	1·8	4·69	**0·8**	·03	·07	·02
12	55	76·81	24·8	1·5	5·72	0·5	·02	·08	·06
13	57	83·75	26·3	2·0	6·94	1·5	·04	·09	·07
14	59·6	93·48	28·2	2·6	9·73	1·9	·04	·12	·05
15	62·3	104·90	29·7	**2·7**	11·42	1·5	·04	·12	·04
16	64·7	120·00	31·2	2·4	**15·10**	1·5	·03	·14	·05
17	66·2	129·19	32·8	1·5	9·19	**1·6**	·02	·08	·04
18	66·5	134·97	34	0·3	5·78	1·2	·04	·04	·02
19	—	—	34·7	—	—	0·7	—	—	·01
20	—	—	35·0	—	—	0·3	—	—	·01
21	—	—	35·3	—	—	0·3	—	—	·01

Heavy type indicates maxima, which will be seen to offer a regular interval and sequence.

Growth of Boys and Girls.—Dr. Bowditch summarises similar tables compiled by him in America as follows: (1) During the first twelve years of life boys are from 1 to 2 inches taller than girls of the same age. (2) At about twelve and a half years of age, girls begin to grow faster than boys, and during their fourteenth year are about 1 inch taller than boys of the same age. (3) At about fourteen and a half years boys again become the taller, girls having at this period very nearly completed their growth, while boys continue to grow rapidly till nineteen years of age.

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[1] From De Brath and Beatty's *Over-pressure*, p. 32.

The same general results have been obtained in England, Mr. C. Roberts finding that girls of thirteen years are as a rule taller and heavier than boys at the same age.

The bearing of the different rates of growth in the two sexes on the methods of healthy education will be discussed in the next paragraph.

The chart on the next page has been copied, by permission of Messrs. Macmillan, from the *Life History Album*, edited by Mr. C. Roberts. It illustrates graphically similar facts to those given in the preceding tables, and the observations, although derived from a different source, support the same general conclusions.

The preceding tables and diagram give averages, and are not necessarily applicable to each individual case. The main point to know for each boy or girl is *whether growth is occurring at a rate which is exceptional for him or her*. Hence the importance of regular measurings and weighings and records of the results. Exceptional growth is most apt to occur at or about the age of puberty. Two points are important in this connection : (*a*) Fatigue, whether of mind or body, may be dangerous when the stress of rapid growth is being undergone. It may be desirable to curtail under these circumstances not only lessons, but also games which involve bodily fatigue ; (*b*) growth in height without a corresponding increase in weight is a danger signal. The average relation between height and weight for each age is seen in the table on page 30. Marked deviations from this, and especially

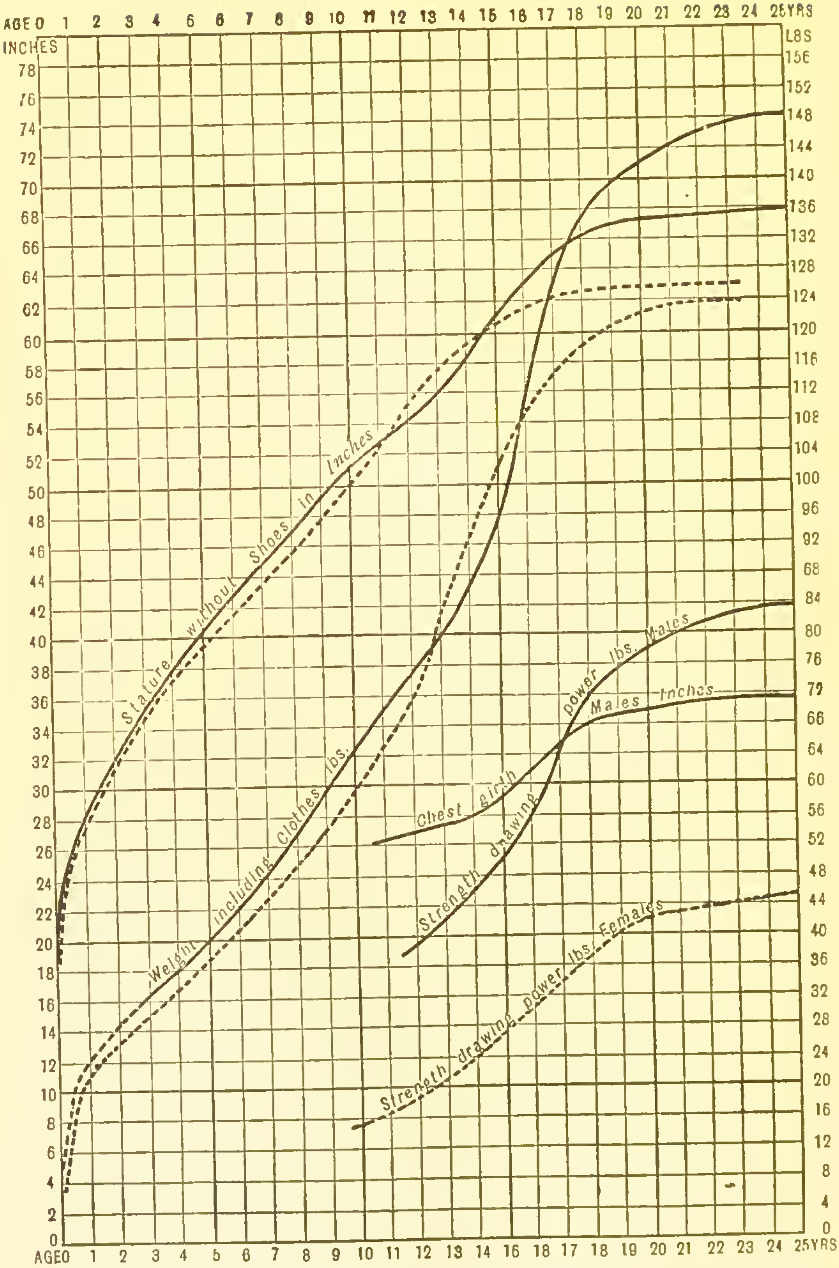

FIG. 1.—Chart showing average stature, weight, chest girth and strength of both sexes, from birth to twenty-five years of age, of the general population of the United Kingdom.

Males ——— Females ....

failure of weight to accompany height, indicate the necessity for seeking medical advice.

Sex in Education.—Most of what has been already stated concerning the bearings of age on school work applies equally to boys and girls. It is important to remember however that, while growth of boys continues till manhood, girls concentrate a great deal of growth in a few years.

Owing to the relatively greater growth of girls from twelve and a half to fourteen and a half or fifteen, it is particularly important that their height and weight should be watched during this period, and any overstrain from examinations or other source avoided. A stoppage of increase in weight or height should receive immediate attention, and even more important, a continuance of growth in a girl who has ceased to become heavier may be one of the earliest indications of threatened consumption.

The period of puberty involves greater and more rapid changes in girls than in boys, and schooling requires to be carefully regulated at this period. Accompanying the changes in other organs, great changes must occur in the brain, new emotions and new phases of mental activity being developed. That the nervous system is unstable is shown by the frequent commencement of epilepsy, and still oftener of hysteria at this age.

A carefully regulated school education is, however, beneficial to girls between fourteen and seventeen, and the effects, which are sometimes ascribed to school work, are more commonly due to defective exercise, late hours and a vitiated atmosphere, and the excitement of novels or of a premature entry into society. An amount of mental work, which would be healthful if followed by active and pleasant exercise, may be injurious when exercise is confined to a walk to and from school unaccompanied by any play.

Undue devotion to music seems to have a specially exciting influence on some girls, and prolonged musical exercises are never desirable.

At certain periods some physicians assert that school attendance should be temporarily suspended. We are not inclined to take this view in the majority of cases. Home lessons should be diminished, long walks or calisthenics stopped, and excitement avoided ; but, as a rule, school attendance will do no harm.

Character of Instruction in Relation to Sex.—Two opposite schools of thought have been vigorously advocated. It is the opinion of one that school instruction should be specially adapted to the peculiarities of each sex, while advocates of the other school strongly insist on the same instruction for the two sexes. Dr. Clarke, in his essay on "Sex in Education," says: "None doubt the importance of age, acquirement, idiosyncrasy and probable career as factors in classification. Sex goes deeper than any of these." While admitting the force of this contention, we should lay more stress on the consideration that instruction should be adapted to the *individual* rather than to the *sex*. Experience has shown that girls, when the other conditions of their life are healthy, are quite as capable of severe mental work, and are as successful in examination work, without subsequent evil effect, as boys. If mental work is well balanced and moderate in amount, if it is carried on by girls who are well fed, who live in a pure atmosphere, and who have sufficient daily exercise and recreation, there is not the slightest reason to apprehend ill-effects from it. Even when the mental work involves occasional strain, it cannot be said to be borne worse by one sex than by the other.

CHAPTER III.

EXCESSIVE MENTAL EXERCISE.

It has been noted in Chapter I. (p. 4) that the contact between separate neurones in the brain is intermittent, only occurring during the passage of nerve currents. The knowledge of the structure and functions of the brain enables us to say that the association-pathways created by mental stimuli increase in number and complexity and are more easily traversed when stimuli of a suitable character are judiciously repeated. In the brains of infants the dendrons and fibres of the nerve cells are only imperfectly developed. In the aged with failing mental powers the brain cells resume the infantile type. It may be inferred that the complete development of the pathways created by mental stimuli and of the different ramifications of the nerve cells of the brain is more important for the attainment of high intelligence than is the actual size of the brain.

As illustrative of the preceding physiological facts, Wildershein watched the experimental exhaustion of the living neurones in a nerve ganglion of a small crustacean, whose skin and body were so transparent that the movements of the neurones could be observed. He found that exhaustion of the neurones rendered them unable to respond to stimuli, that their contents became turbid, and that small vacuoles appeared in their substance. Hodge found that under similar circumstances the nerve cells of higher animals changed, their contents becoming turbid, and vacuoles appeared in the protoplasm. These changes disappeared during subsequent repose.[1]

The occurrence of excessive mental exercise is shown in a pupil: firstly, by the diminution of the mental powers, such as perception and memory; secondly, by physical fatigue; thirdly, by impairment of the sensation of touch; fourthly, by certain facial expressions. On each of these points, certain experimental work has been done which will now be briefly indicated.

1. The Diminution of Mental Powers.—Numerous *experimental observations on children* have been summarised by Kotelmann.[2]

Sikorsky in 1879 made various tests, including 1,500 dictation tests with 40,000 letters. He found that in work done after four to five hours of study and recitation there was an increase of 33 per cent. in the average number of mistakes.

Burgerstein[3] devised five series of twenty examples of simple addition of equal working value, arranging that each series should occupy ten minutes, and a pause of five minutes be given after every ten minutes' work. The work was done chiefly during the first school lesson in the morning by boys and girls between eleven and thirteen years of age. Every wrong figure was counted as a mistake. As might have been expected, the work performed, owing to practice, increased in every consecutive period. But the mistakes and corrections — the latter indicating foregoing errors detected in time—increased in a higher proportion. Thus:—

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[1] *Over-pressure*, by S. de Brath and F. Beatty, 1899, p. 19.

[2] *School Hygiene*, by Ludwig Kotelmann, M.D., pp. 19, 28 (American translation, 1899, p. 179).

[3] "The Working Curve of an Hour: an Experiment Concerning Over-pressure of Brain," by Dr. Leo. Burgerstein (*Trans. Inter. Congr. Hyg. and Demog.*, 1891, vol. iv., p. 87).

BURGERSTEIN'S EXPERIMENTS.

The Figures, Errors, Corrections increase in the following percentage proportions.	Figures.	Errors.	Corrections.
From the first ten minutes' time to the second	14·8	51·5	58·2
From the first ten minutes' time to the third	25·3	136·3	162·8
From the first ten minutes' time to the fourth	39·5	177·3	194·0

During the first ten minutes 3 per cent., during the second 4 per cent., during the third 5·7 per cent., and during the fourth 6 per cent. of errors occurred. It will be noted that the mistakes increased most in the third ten minutes, the difference between this and the fourth ten minutes being but slight. Burgerstein explains this interesting fact on the hypothesis that during a portion of the third ten minutes "a relaxation of the mental intensity takes place, as if the children *unconsciously must repose*". Burgerstein concludes from his experiments: "It seems then best not to let lessons last longer than three-quarters of an hour; and to interrupt the continuation of lessons by pauses of about a quarter of an hour, so as to have the children's brain rested, the body moved, and the schoolroom air changed".

Laser in 1894, having come to the conclusion that "it was self-evident that the minds of children would finally get fatigued with so much counting inside one hour,"[1] set himself to study the fatigue arising from the customary five hours of morning instruction in a German school. He set the pupils examples similar to those of Burgerstein in the first ten minutes of each of the five hours. He found that (1) the number of additions and multiplications, *i.e.*, the ability to work was least in the first hour; (2) the amount of work increased up to the third or fourth hour, diminishing in the fourth or fifth hour respectively; (3) the number of errors increased up to the fourth, but was less in the fifth hour; (4) the number of errors increased up to the fifth hour; (5) the number of children making no mistakes decreased from the first to the fifth hour.

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[1] Kotelmann, *op. cit.*, p. 175.

Januschke obtained results on duration of lessons, confirming Burgerstein. Twenty-nine pupils to whom was given mathematical work obtained in four successive quarters of an hour, 493, 576, 566, 511 results respectively. Thus the work was the least in the first quarter of an hour, evidently on account of deficient application, and best in the second and third quarters of the hour. Januschke's results on the best method of memorising are also valuable. Series of twelve unconnected words were presented to the pupils in various ways, and the number in each series retained by the memory was ascertained, with the following results:—

TWELVE UNCONNECTED WORDS.

		Proportion per cent. remembered.
1	Heard only	58
2	Read silently from blackboard . . .	61
3	Read aloud	64
4	Written from hearing	76

2. Physical Fatigue.—Keller (1893), acting on the hypothesis that mental fatigue is due to chemical changes affecting the blood, and through it the muscular system, tested a boy by taking his muscular-fatigue curve by means of an ergograph. Without detailing the methods by which the curve of muscular contraction can be measured, it suffices to state generally that Keller found that mental application was first stimulating, not fatiguing, to the muscular system, since after fifty minutes of study the pupil experimented on could accomplish twice as much muscular work—as tested by the ergograph—as at the beginning of the time. The power of muscular work then diminished, and fatigue began to show itself. Continuous mental labour produced greater fatigue, and fatigue more quickly, than when interrupted by short periods of rest.

Further experiments on the same lines by Kemsies (1896) showed "a diminution in muscular energy—or what means the same thing, fatigue of mind and body—sets in after only a brief period of mental labour". It disappears "in one or two hours if a change is made in the work, especially if the change is from a hard to an easy subject. Severe mental fatigue, as measured by the ergograph, comes on with great regularity in the periods of mathematics and gymnastics; while, on the other hand, recuperation seems to take place during the periods for history, geography and nature-study. Modern languages occupy with respect to fatiguing power a middle place. Singing and drawing, moreover, make rather greater demands on those who do well in these branches." [1]

The Position of the Hand gives useful indications. In normal children when the hands are held out in front of them at the word of command they are pronated (*i.e.*, the back of the hand is uppermost) (Fig. 2 (*b*)), and both arms are horizontal on a level with the shoulders; in nervous and excitable but weak children the position shown in Fig. 2 (*a*) may be taken, the wrist being slightly dropped and the fingers bent upwards; in exhausted children the whole hand and wrist may drop, as in Fig. 2 (*c*). The thumb only may drop or all the fingers.

Balance of the Head.—The head is held erect without effort if the child is fresh, but when tired the head leans forward or to one side.

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[1] Kotelmann, *op. cit.*, p. 181.

3. Impairment of the Sense of Touch.—Griesbach's observations (1896) showed that brain fatigue diminishes the sensibility of the skin, and he employed this fact as a method of measuring mental fatigue. The distance between which the two blunt points of a pair of compasses applied to the skin were perceived as separate was the test employed, the normal sensibility of the skin on Sundays and holidays having been first ascertained. Judged by this method, the commencement of study at 7 A.M. is not to be recommended, probably because insufficient sleep had been allowed. Wagner found that the study of mathematics depressed the sensibility a third more than the study of religious knowledge or drawing. Griesbach concludes that the intervals between lessons are often too short, as they do not suffice to restore the sensitiveness of the skin to its normal point. The sensitiveness was least during afternoon work.

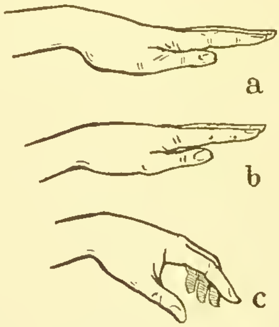

FIG. 2.

(*a*) Hand-balance tense.
(*b*) ,, normal.
(*c*) ,, relaxed.

Combined Tests.—Dr. Warner has attacked the same subject from a wider standpoint.[1] He divides his study of children into a study of neural and mental defects.

Neural defects may be studied by observation and description of "nerve signs," which are either spontaneous or elicited by stimulation through the eye, the ear, or otherwise, and may be normal or abnormal. As pointed out by Dr. Warner, the study of movements affords the readiest means, almost the only means, of studying brain action. The face is a most accurate index of brain action. Among facial signs are the following :—

Frontal muscles overacting, causing horizontal creases in the forehead.

Corrugation or knitting of the eyebrows. This sign when alone is often associated with a "status of mental stress which may be discovered on further inquiry".

Orbicularis Oculi (*i.e.*, the muscle around the eye) *relaxed*. This causes the lower lid to appear baggy and relaxed.

Mouth open. This may be due to chronic obstruction in the naso-pharynx or be due merely to muscular relaxation.

The above is not a complete description of all the neural defects described by Dr. Warner, but the signs enumerated are those which are most likely to be useful to the teacher and can be most readily recognised by him. Apart from these there is a facial expression indicating exhaustion which, although it cannot be easily described, should not fail to be observed by the teacher.

Dr. Warner also records the condition of nutrition and mental capacity of each child examined, and by these means is able to classify children according to their capacity for work. The complete carrying out of his method of observations requires an expert observer, but the muscular and physiognomical indications given above furnish valuable indications which every teacher will be wise in utilising.

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[1] "Neural and Mental Defects in Children" (*Twentieth Century Practice of Med.*, vol. xx., 1900) ; "Mental and Physical Conditions among 50,000 Children seen 1892-93" (*Jour. Roy. Statist. Soc.*, vol. lxx., Part I.).

The preceding description will indicate some of the lines of observation which will enable the teacher to detect the symptoms of mental fatigue in his scholars, and to apply the necessary remedy in rest or change of occupation. Much skill will be required in discriminating between natural dulness, dulness due to inattention or carelessness, and dulness caused by over-application; and it is only by careful study on the part of the teacher of individual scholars that mistakes can be entirely avoided.

The most common symptoms ascribed to **mental overstrain** are headache and sleeplessness, often combined with a general fidgetiness and irritability, and the indications furnished by muscular contraction or relaxation to which Dr. Warner has drawn attention, including those shown in Fig. 2.

Such symptoms are in our experience more apt to occur in girls than boys. They are rare among the children at elementary schools. Symptoms ascribed to mental overstrain commonly have a more prosaic source, in deficient food, insanitary or unwholesome conditions of home life, or defect of eyesight (p. 88).

Chorea (St. Vitus's Dance) has been ascribed to excessive school work. That it most commonly occurs during school ages is certain; but it is now well established that it is rheumatic in origin. One of us (A. N.) has shown that its curve of monthly and annual incidence in London and elsewhere coincides exactly with that of rheumatic fever. School life can therefore have at most only a predisposing or determining influence. Rheumatic fever and chorea are probably both infective diseases. They occur, however, chiefly in certain families; it is therefore a good rule that children having a family history of either of these diseases should be carefully guarded against overwork, which by causing a diminution of the normal resistance to disease probably would increase the tendency to their occurrence.

Mental overstrain may arise in elementary schools when children resume attendance at too early a date after acute illnesses, particularly after infectious diseases. For this reason absence from school for a considerably longer period than is required to free the child from infection is desirable. In Brighton the rule is to serve a notice on the parent and on the teachers of the elementary school attended by the patient when the latter leaves the isolation hospital. This notice requires the ex-scarlatinal patient to be kept away from school for a further month, and the ex-diphtheritic patient for six further weeks. For other acute illnesses similar rules should apply, school attendance only being resumed when the child's health is re-established (see page 149).

Ordinary school work, interrupted by vacations and not burdened with home lessons, seldom produces excessive strain on the mental powers of children. It is only in exceptional cases, in which children are insufficiently or imperfectly fed, or do not properly assimilate their food, or are of a peculiarly excitable temperament, or when the hours of study are unduly prolonged, that this result is likely to ensue. Such overstrain may also occur when one particular class of work is persisted in to excess, to the exclusion of varied work and of recreative exercise.

In such cases **Headache** is one of the first symptoms to attract attention. The parent is a much better judge as to whether the school work is overtaxing a child than the teacher, as the latter has to deal with a large class and can scarcely watch with sufficient care each child. Moreover, the stimulant effect of school life may postpone the reaction of exhaustion until after the child has reached home. If a child frequently complains of headache, it may be due to overwork, though the far more frequent causes—such as indigestion, a vitiated atmosphere, defects of vision —should first be eliminated.

Many children seem indolent and stupid in school. The proper remedy for this, in many cases, is *not* some form of punishment, but attention to the general state of health, or sometimes a relaxation of studies. In some cases **apparent stupidity** is really due to some defect of vision or hearing, a form of "artificial stupidity" which is discussed on p. 46.

The brain may in rare cases become congested from overwork, but brain fever (tubercular meningitis) cannot be ascribed directly to school work. It is common both before and after the school period of life, and is due to infection by the same microbe as causes consumption of the lungs. School work (like any other form of excitement) may conceivably precipitate an attack in delicate children.

Too prolonged study is a mistake, from every point of view. It defeats its own ends: the mind cannot assimilate knowledge at more than a certain rate; and excessive tasks make study distasteful. It assumes, furthermore, that the *acquisition* of knowledge is everything, forgetting that the *organisation* of knowledge, for which time and thought are required, is the essentially important matter. "It is not the knowledge stored up as intellectual fat which is of value, but that which is turned into intellectual muscle."—(Herbert Spencer.)

Perhaps the greatest evil resulting from too prolonged study is its interference with the due development of the whole body. This occurs because insufficient time is allowed for exercise, because the digestive and assimilative powers for food are diminished, and to some extent because the flow of blood is partially diverted from the muscles to the brain. Even supposing that increased mental power *is* the result, the general physique necessary to make it available in the battle of life is wanting; unless a man is a "good animal," one of the first requisites for success in life is absent. But increased mental power is not the result. The abnormally rapid advance of any organ in respect of structure involves premature arrest of its growth. A forced brain usually falls short, in the end, of the normal standard of size and power.

The Means of Recognising Mental Overwork may be gathered from the preceding description of its symptoms. The responsibility for this recognition rests jointly with the parent and the teacher.

If a regular record has been kept of the scholar's height and weight, deviations from the normal rate of progress offer very valuable indications. Failure of appetite and lassitude indicate the necessity for medical examination of the child. Twitching of the muscles, pallor, a facial expression of anxiety, knitted brow, and baggy under-eyelids indicate the same necessity. Failure to sleep well is a bad sign.

In considering the hygienic conditions of school life, which if neglected may lead to mental over-pressure, or to defects of physique or mental power, it will be convenient to consider in chapters following the next, the subjects of—

The daily programme of school work.
Home work.
Vacations.
Examinations.
Punishments.
Food and Sleep.
Unwholesome surroundings.

CHAPTER IV.

THE CARE OF ABNORMAL CHILDREN.

MANY children, in consequence of physical or mental defects, cannot legitimately be brought within the scope of ordinary school work. Occasionally much unintentional cruelty is caused by attempts to force such children to do work for which they are not fitted. Without attempting a complete classification, the following groups may be mentioned in their bearing on school hygiene:—

1. Artificially stupid children.
2. Completely deaf, deaf-mutes and blind children.
3. Feeble-minded children.
4. Imbeciles.
5. Idiots.

Artificially stupid children are those who are abnormally dull at school work in consequence of some defect, usually of hearing or eyesight, which may be completely or partially remediable. Defects of eyesight causing artificial stupidity are dealt with in Chapter VII., pages 102 to 106.

Defects of Hearing are far from common in school children. The hearing of every child who appears to be dull and inattentive ought to be carefully tested as well as his eyesight. This is an additional reason for lessening the number in each class, a reform which we have urged on page 70. The teacher himself can then make a preliminary test, a doctor being referred to for exact information and advice. The acuteness of hearing can be tested by holding a watch at known distances from the ear of the child, who is blindfolded, the opposite ear being blocked with a little cotton-wool. The greatest distance from each ear at which the ticking of the watch can be heard is measured by a tape and recorded and compared with the corresponding distance when a person known to be possessed of normal hearing is tested. The preceding test is not satisfactory, even with the child blindfolded. A more satisfactory test is for the teacher to whisper with a uniform intensity various numbers, *e.g.*, 23, 37, 45, etc., to the scholar, who is placed so that he cannot see the lip movements of the teacher. The distance between the scholar and the teacher will be greater in this instance than with the watch test. In each test a scholar with normal hearing may be taken as a standard for distance.

Defective hearing in children is commonly the result of attacks of measles or scarlet fever, in the course of which the drum of one or both ears has become perforated and the middle ear injured. Unfortunately this condition is almost irremediable.

Another common cause of defective hearing is happily curable. At the back of the pharynx above the arch of the soft palate and between it and the back part of the nose the mucous membrane in delicate children frequently become so swollen as to block up the passage between the nose and the throat, and thus compel the patient to breathe through his mouth. The growths of the mucous membrane thus produced are known as **adenoid growths.** Not only is the patient unable to breathe freely through the nose, but he gradually becomes increasingly deaf, owing to blocking of the lower ends of the Eustachian tubes, leading from the throat to the ears. Not being able to hear the teacher, he ceases to attend to lessons, and becomes mentally dull. Such children are easily recognised. Their general appearance is that shown in Fig. 3, taken from an illustration of an article by Dr. Watson Williams.

The face is elongated, and its natural folds are partially obliterated; the patient keeps his mouth open, and looks "stupid" and dull. He "speaks through his nose," or rather his voice has a nasal quality. He has difficulty in blowing his nose, and there is usually a chronic discharge from the nose. Such children are more apt to contract infectious diseases, especially diphtheria, than others; and attacks when they occur are more severe. If attacked by scarlet fever, both ears are usually permanently injured.

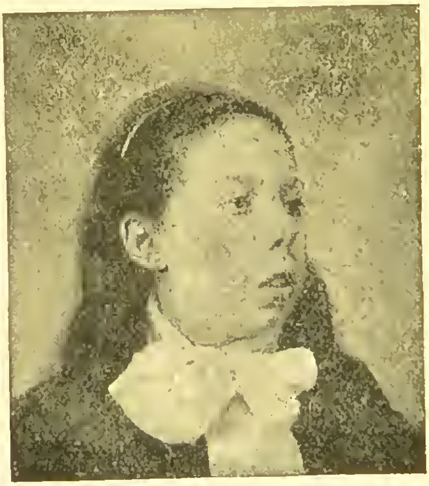

FIG. 3.—The typical facial aspect due to post-nasal adenoids.

Adenoids are easily cured by a simple operation. The child then rapidly regains his power of hearing and of learning, and his face resumes an intelligent aspect. He is now able to keep his mouth shut when not speaking.

It is not necessary here to enter into the scholastic treatment of children who are deaf or blind or deaf-mute, as the principles of such treatment are now well understood.

Nor need we enter into the special treatment of idiots or imbeciles, as this is well organised. The treatment of feeble-minded children has, however, until recently not received the attention it deserves. It is not necessary strictly to define the condition, were it practicable. Dr. Shuttleworth[1] regards idiocy, imbecility and "feeble-mindedness" as but three gradations of mental defect (from below upwards) which shade into each other, and have no sharp dividing line. The Elementary Education (Defective and Epileptic Children) Act, 1899, empowers School Authorities to make further provision for the education of defective and epileptic children in their districts. Where a School Authority wishes to make this provision, the arrangements made must enable each parent to present his child to the School Authority for examination, and a certificate must be obtained from a duly qualified medical practitioner, approved by the Board of Education, in the following form :—

(*a*) FOR DEFECTIVE CHILDREN.

I, A. B., a duly qualified practitioner, approved by the Education Department, certify that Y. Z., not being imbecile and not being merely dull or backward, is, by reason of (1) mental, or (2) physical, defect, incapable of receiving proper benefit from the instruction in an ordinary public elementary school, but is not incapable, by reason of such defect, of receiving benefit from instruction in a certified special class or school.

(*b*) FOR EPILEPTIC CHILDREN.

I, A. B., a duly qualified practitioner, approved by the Education Department, certify that Y. Z., not being idiot or imbecile, is unfit, by reason of severe epilepsy, to attend an ordinary public elementary school.

(NOTE.—The causes which render an epileptic child unfit to attend an ordinary school may be either that serious danger to itself or to other children, or that serious disturbance to the work of the school, would be caused by such attendance.)

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[1] *British Medical Journal*, 26th October, 1901, p. 1252.

The provision made may be by means of a special day school or class; the size of the class is limited to an average attendance of twenty, or of thirty if there are more than two classes. The School Authority may also board out defective children at special schools. Clearly the Act is not intended to apply to merely dull or backward children, *i.e.*, there must be an inherent defect, the mental dulness present not being caused merely by neglect or unfavourable surroundings. If care and nursing rather than special instruction is required, it would be preferable to certify the case as imbecile (Shuttleworth). The Departmental Committee on Defective and Epileptic Children[1] came to the conclusion that "feeble-minded" as distinguished from imbecile children probably constitute 1 per cent. of the school population. The school population forms about one-fourth of the entire population.

Treatment of the Feeble-minded.—It is important that such children should receive early training specially suited for their condition. For this some provision, as already indicated, is now being made. The period of school age for such children is extended to sixteen, which is a step in the right direction. As pointed out by Dr. Shuttleworth, however, the limit should be more elastic, and continued training, especially in industrial work, is necessary in most cases after sixteen. He is of opinion further that "for the majority of cases permanent care in the form of an industrial colony, whereby the risks of the reproduction of the unfit would be minimised, would, though costly in initiation, prove in the long run the most economical plan in view of the interests of succeeding generations".[2] Further particulars of this important subject are given by Dr. Shuttleworth in a paper on "The Treatment of Children Mentally Deficient".[1]

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[1] Eyre & Spottiswoode, 1898.

[2] *British Medical Journal*, 26th October, 1901, p. 1253.

Vicious Habits.—The practice of masturbation may be appropriately mentioned here, as its occurrence is regarded by many as an indication of feeble mental calibre. This is, however, by no means the rule. There is reason to fear that in certain boarding schools it is very prevalent. Among its chief causes, apart from the inherent defect that may be present, are the influence of evil example, of obscene books, pictures and exhibitions, and of local irritation. For the latter, and in all suspected cases, medical advice should be sought. Boys addicted to such practices may show enfeebled memory and reasoning powers and may become mentally depressed. These consequences only occur in exceptional cases, and exaggerated statements are to be deprecated, as they may cause mental depression in the victim. Gymnastics, cold bathing, and a complete absence of stimulants are helpful. Addresses on the subject to entire classes of boys are, as a rule, inadvisable, but there should be an individual appeal to the higher nature of each boy; and nothing is so calculated to prevent such habits as the inculcation by every possible means of a high moral tone among scholars.

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[1] Address to the Union of Teachers of the Deaf on the Pure Oral System, 12th December, 1895.

CHAPTER V.

THE SCHOOL PROGRAMME IN RELATION TO HYGIENE.

A STUDY of the physiological and experimental facts given in Chapters I. to III. suggests important practical lessons as to school work.

1. **The School Year.**—The school year is divided into terms by periodical holidays. In schools for the middle and upper classes there are three terms, with holidays between each, the longest varying in length from six to eight weeks. The total holidays are usually about twelve weeks. In elementary day schools usually three or four weeks' holiday are given in the summer, a week at Easter and a fortnight at Christmas. This amount is ample so far as pupils are concerned. The longer holidays in the first class of schools are rather for the benefit of teachers than of pupils, and might with advantage to the curriculum be curtailed. If shorter holidays were given, the necessity for working at high pressure in preparation for examinations would disappear, and school work could be more steadily and effectively accomplished. The longer holidays cannot be shown to be hygienically necessary. The object of the holiday is the mental and bodily recuperation of scholars and teachers. For this purpose, a month's summer holiday, and a fortnight each at Christmas and Easter amply suffice.

The Education Code limits the length of holidays in elementary schools by stating that a school must have met not less than 400 times in a year, *i.e.*, on 200 days. As these schools meet on five days in the week, this implies a maximum of twelve weeks of annual holiday. In practice this length of holiday is seldom given.

2. The School Week.—This generally consists of five days, or of four days and two half days. If the day's curriculum is properly arranged this cannot be called excessive.

3. The School Day.—In elementary schools in England the school day is usually divided into a morning session from 9 to 12 and an afternoon session from 2 to 4 P.M.

This plan is bad, unless there is half an hour's recess for play and light lunch in the middle of the morning's work. In other than elementary schools two half-holidays in the week are arranged instead of a whole-day holiday on Saturday. This is a better arrangement, as it ensures a semi-weekly break of work, and prevents the frequent waste of Saturday morning in indoor non-recreative occupations.

Duration of Lessons.—The experimental facts given on pages 36 to 40 show that the most fruitful work is done in the first thirty to forty minutes of each hourly lesson. This plainly indicates the desirability of curtailing lessons like arithmetic and languages, which involve a tax on the reasoning powers or memory.

The brain becomes fatigued when attention to one subject is prolonged. Much better results can be obtained in an hour's lesson by devoting five or even ten minutes in the middle of it to drill exercises, than if the whole hour is devoted to mental work. Lessons should never exceed three-quarters of an hour, even for elder scholars, and half an hour is preferable. Singing or drill exercises for a few minutes in the interval arouse the nervous energies, and facilitate subsequent attention to work.

An adult experiences the utmost difficulty in keeping his attention concentrated for an hour, if he is really *learning* the whole time. Children having had a shorter mental training cannot maintain the strain of learning for more than fifteen or twenty minutes; and attempts to force them to concentrate their attention on a subject for longer periods cause such an amount of mental fatigue that they do not recover during the few minutes' interval. Consequently, during the rest of the day they remain partially fatigued, and cannot learn properly.

For infants' classes even shorter lessons than indicated above are desirable.

The following remarks from the *Revised Instructions* issued by the Board of Education on the Education Code for 1901 are eminently judicious:—

> "The instruction of infants' schools and classes must be adapted to the tender age of the scholars. The length of the lessons, therefore, should never exceed thirty minutes, and would be better reduced to fifteen or twenty minutes, and the lessons should be varied in length according to the section of the school. In the babies' room, which should always, where circumstances permit, be separated from other rooms by a partition (movable or otherwise), and should contain abundant space for games and exercises, the actual work of the lesson should not be more than a quarter of an hour. Each lesson should be followed by intervals of rest and singing. It is evident, therefore, that older girls and boys, who do not need these intervals, and require longer lessons, cannot be considered suitable pupils in an infant school merely on the ground of their ignorance. Though the methods of teaching are similar, such children require a somewhat stricter discipline and lessons of greater length. They do not find the songs and games of the infant school attractive, and they are not fit companions for very young children in the playground. Though no rigid rule as to age

> can be applied, especially in the cases of delicate and afflicted children, it may be safely laid down that backward scholars of advanced age would make more progress in knowledge, and form better habits, in a school for older scholars than in an infant school."

Home Lessons.—In many schools the school work is not excessive, but home lessons are frequently given which require prolonged attention, and leave too little time for meals and recreation. Parents can sometimes best judge as to whether home lessons are doing harm, and they should at once communicate with the teacher, if any indications of overwork appear. For any pupil, home lessons, if given at all, should be reduced to a minimum, and should never, except in higher forms in grammar schools and high schools, exceed an hour, unless there is no afternoon school. They should furthermore not require to be done in the evening, and should take the form of recapitulation of work done during the day and not break into new ground.

In elementary schools there is usually little cause for complaint as to home lessons. In grammar schools and in high schools for girls the hours of study out of school are often protracted to a dangerous and even injurious extent. The amount of work thus exacted is often so great as to justify the suspicion that *the teacher in question regards his work not as teaching, but as hearing and setting lessons and examining home work.* If in these schools evening work is ever exacted, the scholar should be required to bring a statement from his parent or guardian as to the number of hours occupied by it: and if this is found to be more than one or two hours (according to the age of the scholar), the amount or character of the home work should be altered.

Probably education would proceed more satisfactorily if *no* home lessons were given in schools in which there is an afternoon session, and we agree with the opinion now frequently expressed that it is usually the inferior teacher who requires most home work from his pupils. On the part of the teacher it is urged that in higher class schools the scholars are required to sit for set examinations in order first to satisfy the parent that his child is making progress, and secondly, to show how admirably the school is conducted, with a view to attracting prospective pupils; and that in view of such examinations a large amount of home work is necessary. We are convinced, however, that any school with average scholars and good teachers would secure excellent results in examinations with a morning and afternoon session without home work, or with a morning session and home work without an afternoon session.

4. Order of Subjects. Arrangement of Subjects in the School Day.—Much can be done to diminish the risk of fatigue by **change of subjects.** Thus languages or history should alternate with mathematics, memory and reasoning being successively exercised. Work, largely mechanical, as writing or drawing, may follow, succeeded by object lessons and experimental lectures. By some such succession as this the best results can be obtained with the least mental fatigue. The introduction of manual instruction and drawing into elementary schools is exercising a most valuable influence on both the mental and physical training of children. The time devoted to manual instruction, while it is useful in itself as an introduction to industrial occupations, has an important bearing (see also pages 10 and 109) on the due development of every part of the brain, and on the maintenance of that balance between different parts upon which healthful and co-ordinated mental action depends.

The Order of Subjects should be arranged so that difficult work is taken first in the day, less difficult work later. Thus mathematics and languages should come early in the day, scientific subjects in which demonstrations are possible may come later, and subjects like drawing, writing, manual training and object lessons latest. Examination work should, whenever practicable, be in the morning (see also page 53).

5. **Hygiene of Special Subjects.**—**Reading** forms an important part of school work, and will, if properly taught, help in securing a high hygienic standard of scholars. Each child should be taught while reading to inspire deeply and quietly, and to articulate distinctly and slowly. His posture is important; he should be erect, with the head upright and not leaning over the book; the latter should be not less than 10 inches from the face, and should be held up so high that the line he is reading should not be more than 2 inches below the level of the eye. Although this may be an awkward position to maintain for many minutes, it is no inconvenience for the two or three minutes during which he is reading. Clergymen's sore throats and similar conditions in teachers may be caused by reading aloud with the head bent forward; and scholars should be taught to avoid this. Simultaneous reading aloud is mischievous, "as tending to distract the teacher's attention from the pronunciation of individual children, and to induce an unnatural intonation among the scholars" (*Revised Instructions*, 1901, page 219). With large classes sufficient time for individual reading aloud cannot be spared. This is a further reason for smaller classes. Writing and reading in relation to eyesight are discussed on pages 20 and 94.

Circular 408 of the Board of Education makes the following useful remarks:—

> As there has sometimes been a disposition to underrate the importance of the subject, it may be worth while to set forth reasons for regarding reading, for teachers if for no others, as of the first importance:—

1. A teacher cannot teach well unless easily understood. Distinctness of utterance implies audibility ; an easy and pleasant-sounding speech secures the attention of those whom shouting and stridency distract and tire.
2. *Good reading is an exercise in voice-economy, and voice-economy is useful in all degrees.* It is *always a saving of physical effort ;* at the least it is a protection against common forms of throat disease to which those who live by talking are prone ; and at the best it is an admirable and health-giving gymnastic. It is a most painful fact that a substantial number of our teachers suffer from more or less developed and recognisable forms of throat disease which a little exact knowledge and careful practice in the earlier stages might have cured, if not avoided. And experiments have satisfactorily shown that even in cases of advanced deterioration carefully graduated exercises have gone far to mitigate the mischief already done.
3. The best reading is evidence of many good physical and mental qualities which are capable of cultivation, though rarely communicable by mere pattern-giving.

Writing should be so taught as not to encourage strain of the eyes from over-accommodation (p. 81) or favour spinal curvature. Composition is of more educational value than dictation ; and by utilising it the total time necessary for sedentary work may be reduced. Vertical script handwriting favours the best postures, and involves the smallest strain on the accommodation of the eye.

Vocal Music is a valuable part of a school curriculum. Besides developing musical powers, and storing the mind with what will probably be a life-long delight, it forms a "healthful and pleasant form of collective indoor occupation," and helps to train and develop the voices of children, and to increase their respiratory capacity.

Drawing is invaluable in educating both hand and eye, enabling the two to act in co-operation, besides its value as a training of the æsthetic sense. Like vocal music, object teaching and manual training it develops mental activities through the senses and muscles, and thus prevents education from becoming too bookish.

Object Teaching has in recent years been very wisely included in the curriculum for elementary schools. As pointed out in the *Revised Instructions* (Appendix IX.) it is twofold in character, comprising observation of and information about the object. It educates through the senses, leading the scholar to acquire knowledge by observation and experience. In the *Instructions* the suggestions summarised below are given :—

1. Do not overburden the list of subjects. Habits of observation are better cultivated by the thorough examination of a few objects (not simply pictures of objects) than by the superficial treatment of many.
2. The Object chosen must be one capable of adequate illustration by examples ; and
3. The children should be encouraged to bring illustrative specimens.
4. They should also be encouraged to make simple drawings illustrative of their observations.
5. Visits to museums, art galleries, etc., are recognised by the Code, and may advantageously be undertaken in connection with the Object teaching.
6. Trained attention is best secured by directing in a conversational way the attention of the children to the different parts of the subject in an orderly manner, and explaining the relation of each to the whole. After the analysis or study of separate detail, the Object should be again treated as a whole.
7. The children should be taught to be not only accurate in observation, but also accurate in description.

The object of these lessons is summarised as follows in the same official report : "The first and most important aim is to teach the children to observe, compare and contrast: the second is to impart information: and the third is to reinforce the other two by making the results of them the basis for instruction in Language, Drawing, Number, Modelling and other handwork". As it should be the chief function of the teacher to instruct the scholar how to learn, these lessons fulfil his highest ideal, and form a model upon which he may base all his teaching. Object teaching possesses the further utility of relieving the strain of routine school work, and of developing a love of nature, an interest in living things and kindness to animals.

Manual Work is of great importance, because it brings into activity the motor centres of the brain (p. 7), besides giving manual skill. It is the most advantageous subject for training habits of accuracy and developing the power of construction, often so much overlooked in the teaching of other subjects.

6. Discipline and Punishment.—In elementary schools one condition of receiving the Government monetary grant is the discipline and organisation of the school. On this point we again cannot improve on the excellent remarks in the *Revised Instructions*:—

> "The most effective agent for maintaining good discipline is the teacher's own example. Children readily recognise that their teachers are anxious to help them, patient, yet determined to be obeyed. They notice also such details in their conduct as punctuality, order, neatness, gentle speech, and imitate what they see and hear. They observe little defects of conduct more keenly still, and with disastrous effect. It is on this account, therefore, that great stress is laid on matters that appear to be unimportant. The punctual, methodical performance of all the duties of the day, however trifling they may seem, is the result of good habits on the part of the teacher and the foundation of good habits in the scholars."

It would be well if teachers could be made to understand that ethically it is quite as important for lessons and school to end punctually as it is for them to begin punctually, and that all breaks and rests should be as punctually observed as lessons.

> "If discipline were perfectly efficient, punishment would be unknown, for the result of efficient discipline is to engender the good habits which render punishment unnecessary. Order, diligence and obedience, which are only maintained by frequent punishment or the dread of it, do not constitute good discipline. Indeed, the infliction of punishment is, to some extent, a confession of defeat by the authority that inflicts it; for the object of discipline is to prevent the commission of faults. *No punishment which excites the emotion of terror in a child should ever be employed.* In an infants' school no punishment should be permitted which causes bodily pain. In schools for older children, corporal punishment should be discouraged as an ordinary expedient in boys' schools, and altogether in girls' schools. The punishment register, which is required in all schools, may serve some good purpose if it induces teachers to reflect occasionally on their methods, and to consider whether these really tend to the formation of the habit of good conduct."

The above represents the ideal, which is quite attainable if a scholar has been under efficient tuition throughout his school life. In many schools, however, there are neglected boys who approach the "Hooligan" type, and for these **corporal punishment** may be occasionally though rarely required. The rules with regard to its use should be that

1. It should be reserved for offences of some magnitude.
2. It should, as a rule, be inflicted only by the head

master. This implies also that it will not, as a rule, be inflicted in the heat of passion, but after some delay.

3. The birch is preferable to the cane, and it should never be applied except to the buttocks. Punishment here is painful, but free from danger. Caning the hands is not justifiable ; and boxing the ears or any other punishment directed towards the head is very dangerous.

In higher grade schools a good plan is to have **a roll of honour**, where each boy's name is suspended in the classroom, and turned or obliterated if he has been guilty of a breach of discipline ; the name to be made permanent when it has not been turned or obliterated for a certain probationary period.

Impositions involving keeping-in scholars for a prolonged period, and interfering with their meals and recreation, should never be given. "Setting lines" is a foolish and useless form of punishment. Setting the culprit to learn *by heart* a number of lines is a better form of punishment. It presents the further advantage that inasmuch as the teacher must stop to hear the recitation, the imposition is not likely to be excessive in amount or too frequently set. The plan of having good and bad marks, which are subsequently reported to parents and made the subject of rewards, works much better than any form of corporal punishment.

Punishment drill to be taken by the teachers in turn is a useful plan. It is good exercise for the scholars, and if the teacher has to take the drill he will not punish without reason ; or if there are several teachers of whom one is always sending children to drill he will soon hear of it from his colleagues.

Punishment without adequate cause, even though it is not excessive, has an undoubted effect upon the character of the scholar ; most adults remember with a sense of injustice punishment which they have received as children for offences of which they were innocent. The teacher cannot therefore be too careful to ascertain that the scholar has really been guilty of the imputed offence. To punish a scholar without allowing him the right to state his defence develops in his mind resentment which is based on an innate sense of outraged justice. Circumstantial evidence alone should not be considered sufficient to justify punishment.

7. Examinations.—Examinations are chiefly sources of danger to older scholars, especially when they are of a competitive character, bringing into action the force of emulation. Girls are peculiarly prone to suffer when subjected to competitive examinations.

We are not, however, prepared to condemn examinations; it would be difficult to discover an efficient substitute. If well conducted, school examinations for scholars over fourteen may possess educational value. They detect weak points, and show how future efforts may be made more successful, while the anticipation of the examination may serve to guide and stimulate the scholar's efforts.

The experience gained in schools conducted on reformed educational lines tends, however, to throw doubt on the educational value of set examinations: they are a simple means of informing the *teacher*, but this advantage may not be without drawbacks to the scholars. The best results of a teacher's work, especially his personal influence on the training of mental or moral powers, and the influence of an upright and consistent example, can, however, never be brought to the test of an examination.

Doubtless the most fertile motive for studying a subject would be the interest it affords; but this cannot be aroused until the scholar enters the subject, and sometimes not even then; hence the necessity for some external definite motive.

Examinations at the best are but a means to an end; they cease to be beneficial when they are made the object of the teacher's tuition, and they are most pernicious when they imply undue strain on children for some weeks before the known date of an examination instead of a steady unwavering system of work throughout the year.

The occurrence of headache, restlessness, irritability, and inability to fix the attention, are finger-posts showing overwork in preparation for examinations, and should ensure temporary relaxation. Examinations, to be satisfactory, should review the work actually done by the scholar. The duty of the examiner is rather to find out how much the scholar knows than to distress him by revealing his ignorance on obscure points. An examination of the former kind may be an encouraging stimulus, while one of the latter kind leaves only a sense of embarrassment and irritation in the scholar's mind, which weakens him for future efforts.

Furthermore, the best scholars are not always the best examinees; and as examination results usually determine the place of a candidate, it may happen that the best examinee and not the best scholar is placed first. Examinations often cover too large a field, with the result that the scholar crams a considerable amount of superficial knowledge soon to be forgotten. How many of us hold certificates in subjects of which we are now profoundly ignorant! A certain amount of knowledge of a given subject speedily acquired is perhaps occasionally a useful possession, but its true educational value is very doubtful. The mental strain in thus acquiring special knowledge is apt to be out of all proportion to the benefit derived from it.

8. Inspection Methods.—The method of inspection in public elementary schools is described as follows in the *Instructions to H.M. Inspectors*:—

"The Inspector will judge the success of the instruction by noticing the conduct of the children during their ordinary lessons, whether the atten-

> tion is keen or languid, whether the children are careful and industrious or idle and slovenly. He may put a few simple questions on the subject of the lesson and also on other parts of the school work. The exercise books, the records of previous examinations, and the papers worked by the children and revised by the teacher will afford further material for forming an opinion. The Inspector may also give valuable help to the teacher in this way; for frequently small errors of various kinds strike a fresh observer though they escape the notice of the teacher, the keenness of whose apprehension may be somewhat blunted by familiarity."

Clearly this revised system—inspection by the Inspector and teaching and examination by the teacher —leaves to the latter much greater liberty. If this liberty is conscientiously and intelligently used it is calculated to produce scholars of greater intelligence than the old rigid system of annual examinations.

As pointed out in these excellent *Instructions*, "the children may be taught less and learn more," the object of the teacher being to make the children observe and infer for themselves rather than to "convey to their minds ready-made information". Thus "progress may be slow, but it will be real and permanent, and the children will know how to gain information for themselves. Next, their memories should not be burdened excessively. Children learn by rote with great ease and imitate readily; the teacher, whilst making good use of this faculty, should endeavour to train the children not to commit words and phrases to memory without thinking of the meaning of what they repeat; he should train them not to learn mere strings of isolated facts but to notice the connection of one fact with another."

The third and fourth points of this circular are further mentioned on pages 66 and 67.

9. Inspection *v.* Examination. — In elementary schools in receipt of Government grants the principle of "payment by results" has been abandoned since 1890, the grant being since determined by the number of children in average attendance at a given school, there being special grants for instruction in special subjects. On this subject a series of *Revised Instructions* have been issued (1901) by the Board of Education, which are summarised in the following remarks:—

The regulations of the Code with regard to the nature and scope of the instruction have been recast with a view of co-ordinating the whole of the school work,

> "Giving more freedom of initiative to individual managers and teachers, and securing a more complete adaptation of the instruction to local requirements. Grants are payable at one of two different rates, according to the suitability of the education given. The following four points are used in determining which of the two rates of grant shall be awarded:—
>
> > "(*a*) The suitability of the instruction to the circumstances of the children and the neighbourhood; (*b*) the thoroughness and intelligence with which the instruction is given; (*c*) the sufficiency and suitability of the staff; (*d*) the discipline and organisation."

It is pointed out that

> The object of the course of instruction is to convey information to the minds of children, and still more to stimulate them to acquire knowledge for themselves. To this end all lessons should be directed, and not merely the "object" lessons which are sometimes supposed to be the only effective method of attaining it.

Although in future Government Inspectors will no longer hold any examinations of individual scholars, except those who require labour certificates, the *Revised Instructions* lay stress on the testing, apart from the periodical inspections of the school, of the *thorough-*

ness of the instruction. This may be effected by (*a*) formal examinations; (*b*) oral questioning at every lesson; (*c*) careful revision of exercise books. It is added:—

> Examinations should not be too frequent; the teacher of the class can hold them with more useful effect than a stranger. The teacher needs to ascertain whether his instruction has gone home; he also can use the results of his examination to make his pupils realise where they succeed and where they fail. A formal examination of a more complete character once (or possibly twice) in a year is useful for exciting emulation and inducing the children to work for an object. No better stimulus to exertion has yet been devised. For this kind of examination extraneous help can be used with great advantage; in large schools, at all events, teachers can exchange classes for this purpose, and in smaller schools the managers may be able to find some qualified person to take part with the teacher in this work.
>
> These are the only examinations it is desirable to continue.

CHAPTER VI.

THE TEACHER'S HEALTH.

THE teacher, unless his work is carried out under the best conditions, is much more apt to suffer from overwork than the scholars. The strain upon his strength, bodily and mental, is greater, and he probably has much less variety of occupation than his pupils. This is particularly so when he teaches special subjects.

Among the chief causes of ill-health among teachers, for which school life is responsible, are—

1. Living in a persistently vitiated atmosphere. On this question see pages 214 to 216.

2. Overstrain of the voice (see page 57).

3. The correction of an excessive number of examination and exercise papers. This last evil is one of serious magnitude in many boys' and girls' high and grammar schools. Teachers may suffer in health from this cause even more than their pupils. In the interest of both teachers and pupils, elaborate and detailed home exercises should be greatly reduced.

Overstrain of the voice and overtaxing of the teacher in other respects are most commonly due to excessive size of the classes. The requirements of the elementary day school Code are given in Section 73 as follows:—

> "In determining what is the minimum school staff required, the Board consider the principal certificated teacher to be sufficient for an average attendance of 50, each additional certificated teacher for an average attendance of 60, each assistant teacher for an average attendance

> of 45, each provisional assistant teacher, each additional teacher approved under Article 68, and each pupil teacher for an average attendance of 30, and each probationer for an average attendance of 20.

"In order that a school may be properly organised it should be arranged that the number of children habitually present at any one time under the instruction of any teacher or teachers should not exceed by more than 15 per cent. the number for which such teacher or teachers is or are considered to be sufficient."

The sentence in smaller type increases the possible number of children habitually present in each certificated teacher's class to 69, and of each assistant teacher's class to 52. Before this allowance is criticised, it will be convenient to make the following extract from the *Revised Instructions* for 1901:—

> "The Code, Article 73, prescribes a minimum staff, without which whatever grant may be otherwise warranted cannot be paid in full, but it does not state that such a staff is sufficient under all circumstances; nor does the Code make any rule about the adaptation of the teachers to the special work required of them. Therefore, before deciding that the staff of teachers is adequate, the special circumstances of every school and the efficiency of its staff must be considered. The number of scholars is one factor in the case, but there are others equally important, the age and sex of the scholars, their intellectual capacity, their health and condition in life, and the planning and equipment of the buildings. . . . No teacher can instruct more than two groups of scholars at the same time, each group usually containing scholars of various degrees of proficiency. Effective assistance therefore should be provided in schools attended by children of all

> ages, even though the total number of scholars is small. Experienced managers recognise this necessity, but it is desirable to point out that the highest rate of grant cannot be awarded where the teaching staff, though numerically sufficient, continues to be practically inadequate."

The Evils of Large Classes.—Clearly the Board of Education intends that the provision of one teacher for from 45 to 60 pupils (*plus* a possible habitual 15 per cent.) should be regarded as a minimum provision of teachers, which will often require to be exceeded in order that the teaching may secure the highest grant. In practice it is commonly regarded as sufficient, and classes of 70 or 80 children are found under one teacher's care. Economical reasons favour such large classes. Educationally, however, and still more hygienically, they must in the interests of teachers and taught be condemned. No ordinary class should exceed 40, in order that the teacher may teach without straining the voice, that the taught may receive a certain amount of individual attention, and that they may not be unduly crowded together. Large classes favour the spread and increase the intensity of infectious diseases (see pages 139 and 167). While a class is being taught the scholars do not occupy the whole of the floor-space available for them (page 299), but are closely aggregated on a portion of this floor-space; and this evil is most maleficent with large classes.

In an infant class, Clause 100 of the Code requires that a certificated teacher shall be supplied for an average attendance of more than 50, and a teacher of over eighteen years of age, approved by the Inspector, for an average attendance of more than 30. In such classes the necessity for personal care is particularly great, and the risk of conveying infectious diseases is particularly great (page 167). No infant class should, in our opinion, contain over 30 children.

Pupil Teachers are persons usually fifteen to eighteen years old, engaged for three years to assist in teaching while pursuing their studies for the scholastic profession. They are not permitted by the regulations to serve in school more than twenty hours in the week, or five hours in any one day, and when they serve in a school for the full twenty hours weekly, ought not to spend more than twelve hours per week in private study and attendance at classes for instruction. It is further required that if pupil teachers attend classes on the morning and afternoon of Saturday, they should be allowed at least one half-holiday during the week. The improved regulations for pupil teachers indicated above diminish the likelihood of overwork. It is still, however, possible that the double strain of teaching and learning, at a time of life when growth is at an exceptionally rapid rate and when the changes of puberty are taking place, may cause a serious breakdown, unless care is exercised. The most important point is that each day an hour at least should be spent in outdoor exercise and recreation.

The welfare of the next generation of children depends largely on the training of those preparing for the profession of teaching ; and in view of this fact, not only should the future teacher's health be carefully maintained, but the excellent advice contained in the following extract from a circular of the Board of Education on "The Training and Instruction of Pupil Teachers" is well worthy of careful attention :—

> But study and book work do not complete the education of these young persons for the work and the life which are before them. A natural history club, a cricket club, a little debating or literary society, a course of university extension lectures, a visit to a neighbouring factory or picture gallery or famous building, a well-planned holiday excursion, may have no visible or immediate relation to the school duties ; but any one of these things is in its own way useful in its influence on the character and general power of the youthful teacher. And it should be the special aim of managers who take an interest in

his career to acquaint themselves with such resources as the neighbourhood of the school presents, and, when occasion offers, to bring them under his notice, and to facilitate access to them. The future usefulness of the teacher depends, not only on what he knows and can do, but on what he *is*—on his tastes, on his aims in life, on his general mental cultivation, and on the spirit in which he does his work. Managers and teachers are requested to bear in mind that, although such qualifications cannot be formulated in a schedule or made the subject of examination, they are nevertheless indispensable as conditions of all true improvement in national education.

The **Study of Hygiene** ought, in view of their important duties, to be made compulsory on all teachers. Without a knowledge of this subject and of physiology which is its underlying science, the teacher cannot carry out his work with the highest efficiency, any more than he can without a knowledge of psychology in its bearing on mental training. Some parts of hygiene are already taught to girl pupil teachers in the subject of domestic economy; and in certain training colleges for both male and female teachers physiology and hygiene are taught; but these are exceptional instances, and the future of the elementary scholars of the country, whether in State subsidised or private schools, can only be sufficiently protected, when a good practical knowledge of physiology and hygiene, as well as of psychology, is demanded as part of the outfit of every teacher.

This is important, not solely because only teachers who have received this instruction can be expected to supervise efficiently the hygienic arrangements of schools, but because such teachers will be required to give that instruction in domestic hygiene, which should be one of the most important items in the *curriculum* of all elementary schools, especially for girls, but which is at present greatly neglected.

This teaching should not be elaborate, but should be thoroughly practical. Economical and good cooking, the relative utility of various foods, and the objections to alcoholic stimulants, should form an important part of it. So likewise should the importance of cleanliness and of fresh air, with practical illustrations from the use of ventilating, cleansing and drainage appliances in the school. The importance of the formation of good habits, especially in regard to all daily physiological functions, should be emphasised. For girls' classes a few lessons should be given in June of each year on the feeding of infants, methods of cleansing feeding-bottles, scalding milk, etc. By this means a large amount of infantile diarrhœa might be prevented.

CHAPTER VII.

EYESIGHT IN SCHOOL LIFE.

AFFECTIONS of vision are among the most common hindrances to school work, and as in many cases the result may be permanent defect in after life, all concerned with education ought to have some knowledge of the structure and functions of the eyes.

The order to "sit up" is the one most often heard in school, and the reasons for its frequent repetition are worth inquiring into. In fact, the whole of school work is influenced by and influences the vision of the child, and by grasping the general principles affecting the physiology of vision a teacher is not likely to go very far wrong in applying them in school practice; whereas even the most conscientious adherence to routine instructions frequently results in a mere caricature of the objects hoped for. For this reason the first part of this chapter will deal only with healthy eyes, and with the differences which occur normally, in some ways to the advantage, and in others to the disadvantage of children as compared with adults.

The Physiology of Vision.—The actual affection of consciousness called vision depends on masses of nervous structures situated in the convolutions towards the back of the brain (the visual centres in the occipital lobes). The light rays acting on the nerve structures in the eyeball set up stimuli which are carried through the optic nerves to these visual centres, and there produce conscious vision. Vision may be greatly impaired (amblyopia) or even blindness result from brain disease without any noticeable defect in the eyes.

The Psychology of Vision.—The intelligent appreciation and interpretation of vision is a function of a higher order, and probably carried out by a different part of the brain structure than that concerned in the reception of the impressions of sight. It is therefore possible to have perfectly clear vision but intellectual perception which is poor or entirely absent. This occurs physiologically, *i.e.*, normally in the abstraction of deep thought, and it occurs in certain acute illnesses when the brain is affected by fever; but there are other cases where from some defect intellectual appreciation of a limited class of things may be defective or wanting. This condition shows itself best in connection with vision, in relation to such conventional signs as words, letters or numbers. In such cases a person may be capable of dealing with numbers when expressed in Arabic numerals, or may be able to recognise and name every letter of the alphabet, and yet be quite unable to comprehend their simplest combination into words. Such "word-blindness" occurs not infrequently as a result of disease in the later years of life; and although rare it is occasionally seen in school children.

The higher intellectual visual centres being late in development many young children present some degree of this condition. It manifests itself in inability to understand the spelling of the simplest words, and in rapidly forgetting again, so that the teacher says the child has no memory. This is a temporary condition for which time is the cure.

Another more general consideration is that whilst the lower and early developed visual centres reach their maturity comparatively early in school life, the higher and comparatively late developed centres are only exercised by effort and with fatigue: they are most amenable to improvement by appropriate exercise which should be the aim of education in later school life.

The education by appeal to hand and eye, which is physiologically sound with young children and which in them involves effort and fatigue, becomes easy after a time, owing to the maturing and development of the lower centres. There is then risk of continuing to work these lower, now well-developed centres, easily and without fatigue, and failing to develop the intellectual areas which can only be worked by effort. Work in the later years of school life which appeals to hand and eye chiefly, and does not involve determined reasoning and intellectual exercise of an original kind, is to a great extent vain repetition, and may be regarded as educationally almost wasted time.

In great contrast to the "mind-blindness" due to want of development is the extraordinary capacity of the lower centres in the same young brains to store away during infancy all kinds of memories. Inattentively and unconsciously the eye receives picture after picture, and probably without any real analysis of their worth stores away their memories in the brain. Each impression so retained has a permanent influence on every future nervous action. The storing of these memories is scarcely voluntary. It is more of the nature of a passive impress, and the character being to a great extent built out of the sum of all such memories, character formation is probably going on faster in the infant department than at any other time in life. The child at this time is almost the victim of its surroundings. In the infant school the cleanliness, brightness and colour of the schoolroom, the wholesomeness of the other children, the neatness of dress (*simplex munditiis*) and sweetness in manner and voice of the teacher may have a more permanent influence than anything she endeavours to teach.

The Physics of Vision.—In order to see any object it is necessary that an optical image of it should be formed on the nerve structures in the eye.

For the formation of an optical image the rays of light require to converge to the image. Naturally, however, rays from an object diverge, or if the object be very distant they diverge so slightly that they may be regarded as parallel. These diverging or parallel rays must be rendered convergent, which can be done by passing them through a convex lens, and if a certain choice is made as to form and material a lens can be obtained which will form a clear image of distant objects at 22·5 millimetres behind its front surface (25 millimetres = 1 inch).

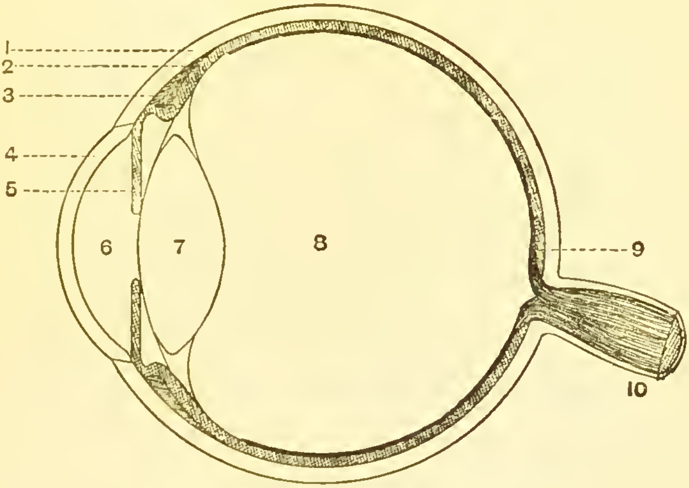

Fig. 4.—Vertical section of the eyeball.

1, Sclerotic; 2, choroid; 3, ciliary body; 4, cornea; 5, iris; 6, aqueous humour; 7, lens; 8, vitreous humour; 9, retina; 10, optic nerve.

Structure of the Eye.—The structures of the normally developed eye constitute an optical equivalent for such a lens. The form of the globe of the eye is chiefly due to its firm external coat of dense fibrous structure called the *sclerotic*, which shows as the white of the eye. This coat makes up the chief thickness of the wall of the eyeball, except behind where it is perforated by the optic nerve, and in front over about one-sixth of the surface where it is replaced by the thick horny but transparent *cornea.*

Over the inner surface of the sclerotic is spread a thick mass of blood-vessels constituting the *choroid* coat; this is covered on its inner aspect by a layer of dense black pigment, preventing reflection of light in the interior of the eyeball. Supported by the choroid and lining the interior two-thirds of the eyeball is the fine transparent nervous sheet called the *retina.* This is of great complexity of structure, and is really an outgrowth from the brain, and in the developing chick it can be traced from the time it is part of the brain wall till it is the retina in the eye, and still connected with the brain by means of the optic nerve. About two-thirds of the distance forwards from back to front the retina loses its complicated structure and is continued as a single layer of thin membrane which, with the choroid, is gathered into a thick mass of tissue surrounding the interior like a collar, and called the *ciliary body.* In front of this again the retina and choroid are continued as the thin contractile diaphragm known as the *iris.*

Suspended in the opening in the collar of tissue which forms the ciliary body is the *crystalline lens*, a structure formed of clear layers of prismatic fibres arranged to form a very elastic lenticular (double convex) body. The lens is contained in a thin capsule which is slung by a number of fine fibrils passing from its margin to the nearest projections of the ciliary body. In the space in front of the lens between it and the cornea is the *anterior chamber* filled with the clear limpid aqueous humour. The rest of the globe behind the lens is filled by an equally clear gelatinous *vitreous humour* or vitreous body; this is surrounded by the retina, and in front the ciliary body and lens.

In the normal eye at rest the light from distant objects falls as parallel rays on the cornea, which causes them to converge slightly; in passing the iris the more peripheral rays of light are cut off, a central beam of light falling on the lens; this powerfully refracts the rays, bending them towards the axis, so that a clearly focussed optical image falls on the centre of the retina, which lies 22·5 millimetres behind the cornea. The numberless impressions produced by the rays of varying colours and intensities in the different parts of the image cause differing nervous actions which result in innumerable separate stimuli travelling along the fibres of the optic nerves to set up conscious vision.

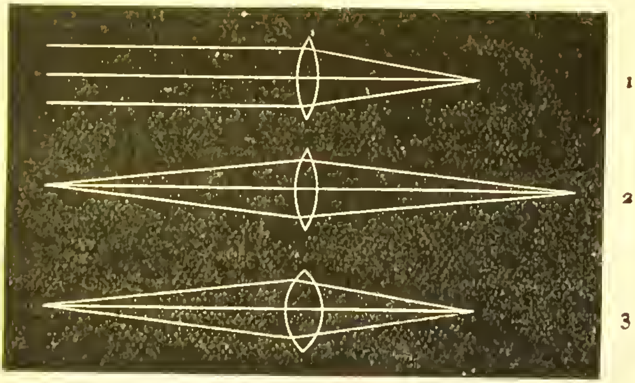

FIG. 5.—Diagram showing effect of a biconvex lens on rays of light. 1, Focus of parallel rays; 2, focus of divergent rays; 3, focus of divergent rays brought nearer by more convex lens.

A lens has been spoken of, of such form that rays from distant objects are clearly focussed in an image 22·5 millimetres behind the front surface. This corresponds in optical action to the eye which focusses distant objects on the retina. The lens of the eye bends light rays to a fixed amount, and will therefore bend the diverging rays from an object which is not very distant, so that they focus farther behind it than the 22·5 millimetres (as in 2, Fig. 5). In order to have the image formed at this required distance, more bending power is required, which can only be obtained by interposing an auxiliary lens, which will be able to convert the diverging rays to parallel before they fall on the original lens. In the case of rays from an object 1 metre distant, the auxiliary lens would have to be such that it could focus parallel rays at a distance of 1 metre. This is about one-fortieth of the effect of the original lens. In the case of an object half a metre away the auxiliary lens would have to be such that the parallel rays would be focussed at a half metre or one-twentieth the power of the original lens, and so on. For every alteration in the distance of the object there has to be an alteration in the power of the auxiliary lens if the image has to remain at a fixed distance, as it does in the eye.

In the case of the eye this alteration, equivalent to the interposition of auxiliary lenses, is effected by a change in the shape of the lens, whereby it is enabled to focus objects from a distance or from within a few inches of the eye, each change in the distance of the object so focussed involving a corresponding change in the lens of the eye (Fig. 5).

The functions of the eye which may be mentioned are :—

1. Adaptation.
2. Accommodation (or focussing).
3. Convergence (or centring).

The **adaptation of the eye** embraces several functions too complicated to detail here. They are chiefly protective. The iris is retracted in a dull light so that the pupil is widely opened and admits as much light as possible. In bright light the pupil may be pin-point in size. In certain nervous or debilitated conditions it is also frequently found much dilated. As a rule on looking at a distance the pupil is somewhat dilated, and for near objects contracted.

The power of detecting differences of light and shade improves after resting the eye from a quarter to half an hour in the dark. It is this that in the narrowest sense constitutes adaptation.

The great functions of importance in school work are those of accommodation, performed by internal muscles in the eyeball, and convergence, performed by the external muscles.

Accommodation.—When the eye is at rest and the gaze is fixed on a near object a distinct effort is felt which corresponds to a certain alteration in the eye. This effort and the changes effected by it are known as accommodation.

The lens at birth is much larger relatively, exceedingly elastic, and more hemispherical than in after life. The structures of the eyeball grow at differing rates, the result being that the small suspensory fibrils which connect the edge of the capsule of the lens with the nearest parts of the ciliary body are habitually tense, and put tension on the inextensible lens capsule, thus causing the lens to be compressed and flattened. By the contraction of certain small muscular bundles arranged partly circularly and partially radially, it is possible for the opening in the ciliary body, against which the lens is slung, to be narrowed, the tissues being drawn a little forward and in, so that the pull of the suspensory fibrils is lessened. When this occurs the tension of the lens capsule relaxes and its compressing effect on the lens diminishes. The elasticity of the lens now comes into play and it tends to resume its earlier form, becoming thicker and more convex.

In this way the crystalline lens becomes capable of bending the diverging rays from near objects to such an extent that, as illustrated in Fig. 5, they meet in focus at the same position as did parallel rays from a distance when the eye was at rest and no accommodation exerted.

It is obvious also that the accommodation depends not entirely on the muscular contraction, but also on the elastic properties of the lens which make it tend to resume its originally thicker and more spherical state when as an indirect result of the contraction of the ciliary muscle the pressure of the capsule is relaxed. If the elasticity of the lens is diminished beyond a certain point, however much the muscles are contracted and the tension of the capsule relaxed, accommodation may fail. From birth the elasticity of the lens steadily lessens, so that the amount of possible accommodation diminishes with age. It is greatest in the young child. When the age of forty is reached it has usually decreased so much that accommodation for objects nearer than about 25 centimetres (10 inches) cannot be satisfactorily maintained, and reading within the ordinary distance becomes difficult.

The amount of accommodation required increases rapidly with the nearness of the object, and consequently the muscular effort required to accommodate is also increased. The alteration in refraction of the eye in changing from the position of rest (distant vision) to the condition required to see clearly an object 1 metre (say 40 inches) distant being taken as a standard, then the change required to see an object at half a metre is twice and at a quarter metre four times as great, so that with every increment of distance by which the object comes nearer the eye there is a very much greater increase in the accommodation required to see it clearly.

The diagram (Fig. 6) represents this relation, and shows that when within a quarter metre (10 inches) from the eye, the increase of accommodation represented by the vertical lines takes place so rapidly that every inch nearer means a disproportionately greater strain on the ciliary muscles.

These statements are based on the proportions of the fully grown and normal eye, which has an axial length of 22 to 23 millimetres.

The Young *v.* the Adult Eye.—If the natural history of the eye be studied, development will be seen to take place from a flattened mass of tissues, which in growth gradually tends to become the nearly spherical eyeball. In the new-born child the eyeball is relatively short antero-posteriorly, with a shorter optical axis than in the adult, and all through childhood this condition, becoming less with age, may be taken as a normal condition for the eye. In such a relatively shortened

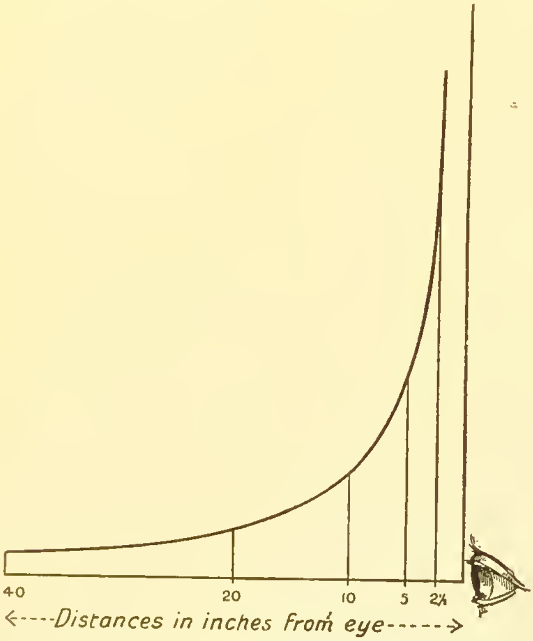

FIG. 6.—Diagram illustrating increasing amount of accommodation required with increasing nearness of object.

eye parallel rays from distant objects will not be clearly focussed on the retina, but are directed to a focus behind it. To get a clear image the lens has to be accommodated so that it bends the rays to a focus on the retina. The developed adult eye sees distant objects without effort when it is in its condition of rest; the child has to compensate by accommodation for the shortness of its eye, and the amount of compensation required is greater the younger the child; so that normally children only see distant objects clearly by using an effort of accommodation, and to see near things they have this effort to make over and above the effort which an adult makes to compensate for the nearness of the object. This is one of the disadvantages from which children suffer.

The fact that in young children, even for distant vision, the minute ciliary muscles are in action almost ceaselessly, involves considerable nervous strain if they are worked up to their full possibilities. These possibilities are greatly diminished in older people; but in young children, owing to the elasticity of the lens, there is always considerable risk of overworking the accommodation, leading to fatigue and ultimately to general nerve strain.

Physiological Law of Work.—Immature and developing nerve cells are particularly liable to exhaustion by continuous work. The natural method of education is for the average work done to be comparatively slight, with at infrequent intervals very great demands for an exceedingly short time. Under such natural conditions an infant would employ its vision chiefly on distant things, and occasionally for an exceedingly short time on near objects. The conditions of school life practically reverse this.

Young children set to continuous work with small objects are not equal to maintaining the strain of accommodation, which, as we have seen, has in their case not only to compensate for the nearness of the object, but also for the comparative shortness of the optic axis of their eyes.

If the attempt to maintain clear vision by muscular effort be given up, some improvement in the impression can be gained by bringing the object nearer the eye. The larger image thus produced, being somewhat out of focus, is confused to an extent depending inversely on the distance; but at the same time the increased illumination causes a brightness which varies inversely as the square of this distance, so that there is a gain in the intensity of the visual sensation from the improvement due to the increased illumination, considerably exceeding the effect of the confusion due to want of clear focussing.

In working continuously with small objects, pupils in the lower school tend to hold their **work** from 4 to 6 inches from the eye. It **ought to be kept at least 10 inches off**, and the chief problem of hygiene in teaching methods is how to effect this necessary working distance.

So far the focussing of the lens to accommodate for distance has alone been discussed, but, as in all optical apparatus, the centring has to be attended to, the best image being that formed in the optic axis.

Physiology of Vision, *continued.*—The human retina is almost peculiar in that, at one small spot, exactly in the optic axis, the sensibility of the retina is enormously heightened. This is known as the yellow spot, or *macula lutea*. The visual sensibility over the rest of the retina is so slight that it would not suffice for the reading of ordinary newspaper type. This can be shown by the experiment of covering one eye, and then steadily fixing the gaze of the other eye on a dot on a newspaper held up at a distance of 10 inches ; if the eye is kept fixed, it is noticed that only the letters over a small area surrounding this fixation point can be distinguished. This area of the newspaper type, which could be covered by a shilling, corresponds to the part of the image falling on the macula. The great difficulty in this experiment is to keep the eye still, for the centring mechanisms are so perfect that any attempt to distinguish a letter causes almost unconscious adjustment of the eye to fix the letter, that is, to centre the eye so that the image of the letter falls on the macula.

Further, another almost exclusively human peculiarity is that the two eyes are adjusted in the orbits so that they look forwards in their position of rest with the optic axes parallel. In most animals the eyes look outwards at an angle, in some in such opposite directions that they have quite different fields of vision, but in the human being the fields of vision of each eye overlap to a great extent, and the eyes are adjusted so that the axes intersect in the object looked at.

The eyeball is placed in each orbit and maintained in position, in a loose mass of soft fatty tissues, by six small muscles, two of which (the oblique muscles) act as auxiliary to the others, and also in helping to steady the globe in rotation. For school purposes the oblique muscles may be neglected.

There then remain the four straight muscles of each eye (internal, external, superior and inferior recti), which cause the eye to turn about its centre of rotation, so that the cornea moves in, out, up, down, or in any resultant direction compounded from these movements.

If, for example, the external muscle of the right eye and the internal of the left are thrown into action, the eyes are rotated to the right and the corneæ are noticed to move in that direction.

The centres controlling movements of the eyes lie far forwards in the brain, being nearest to the large silent area of the frontal lobes which are generally supposed to be associated with complex intellectual processes. The highest intellectual functions involve a concentrated mental action which is generally associated with some slight stimulation of the neighbouring areas of the brain, in that the eyes, for instance, are fixed into a motionless gaze ; the integrity of the parts effecting such concentration can be presumed if the control of the eye centres is elicited, as a rough test, by directing a child to fix its gaze on a small object held up a yard or so off. A child which cannot definitely fix and maintain its gaze when directed to do so may be judged to be wanting to some extent in intellectual qualities.

On the other hand, children who are backward, from want of development, caused either by disease or by lack of education, as Warner has pointed out, often show lack of power in the voluntary movements which should be effected by the eye muscles. If told to watch the movement of a finger or pencil held up before them and moved from right to left, and *vice versâ*, they rotate the head instead of rotating the eyes. This is a rough but useful test for feeble-mindedness in children.

If the gaze be fixed on a distant point the eyes are said to be in the position of rest, with the axes parallel. To fix the gaze on a nearer object both internal recti muscles are contracted, rotating the globes inwards till the optic axes intersect in the object looked at. This action is termed convergence.

Convergence or Centring.—The convergence is effected by the contraction of the internal recti muscles, and the amount of muscular contraction required to maintain this convergence increases with the nearness of the object. Whether by long continued association and inheritance a linking of accommodation and convergence has come about cannot be discussed here, but there is an intimate connection in the nervous mechanism of the two functions, so that when the eyes are converged to a certain distance accommodation is also effected for that distance, and any considerable deviation from this relationship can only be obtained and maintained by a considerable nervous strain.

Nervous Strain from Use of the Eye Muscles.—The continued overuse of one of these muscles, or of one set of muscles, is a most frequent cause of headaches, pain and general nervous disturbances. Apart from cases where a slight weakness of one muscle causes over-action and pain or neuralgia, as in cases where a tendency to squint is habitually corrected (*latent squint*), severe pain may result, more especially in older children or adults, from mere overuse of the eyes, as is common in young pupil teachers and students with quite normal eyes, from overuse of the muscles of convergence, or in many people from continual use of one set of muscles, *e.g.*, one external and the other internal rectus, in looking out of the carriage window in railway travelling.

The "academy headache," from continuous exertion in raising the eyes, is notorious, and in another way is not uncommon in the physically powerful cyclist who with horizontal back keeps looking ahead, straining the superior recti muscles of the eyes and inducing headache even with normal, *i.e.*, distant, sight.

Headaches, unless due to astigmatism (page 105), are distinctly rare in school children below the age of ten. When they occur the cause is much more commonly found in the breathing of polluted air.

In the case of the child with short ocular axes excessive accommodation is needed to compensate for the shortness of the eyes, and if the corresponding amount of convergence is exerted there is an excess of convergence over what is necessary ; this means that the eyes are turned in too much, and as one eye is possibly a little better either in function or relative position than the other, the object is "fixed," that is, looked at by the best eye, the other being inturned to an excessive amount, constituting inward squint. This is a common condition, which may be the result of engaging the child in fine near work, or may merely be the result of some debility, temporary or otherwise, affecting its capacity to maintain the strain necessary to make up for the difference between convergence and accommodation. If there is great defect in the development of the eye, or other defect in vision, the squint, which in such cases usually starts before school age, may be permanent, but in the majority of cases either with the re-establishment of health or with natural growth it passes off.

Visual Acuity.—The exceedingly acute vision attained by a small part of the retina in the optic axis, at the part known as the *macula lutea*, or yellow spot, has been spoken of. There is a possibility that although the anatomical structure is there at birth, the functional development of this visual acuity may be comparatively late, infants not seeing quite as well as they ultimately will, because the nerve structures of the eye are still immature. A great improvement in visual acuity occurs between the sixth and seventh birthdays, and careful examinations can be made which exclude the possibility of any mental lack of development explaining the improvement. It seems probable that full macular visual acuity is attained between the fourth and eighth years.

Eye Work in Infant Schools.—The functions of the eyes and their development in early years of school life have now been traced. From consideration of these it is evident that in the infant department the greatest consideration must be paid to eye work. The infant cannot see so well because—

1. In a considerable proportion the actual nervous mechanism is not fully matured to give or interpret the full value of the image on the retina.
2. The accommodative and convergent strain cannot be maintained for long.
3. There is required an excess of accommodation to compensate for the shorter eyeball.

The indications from these conclusions are (*a*) to exclude very fine work from infant schools, and (*b*) to insist on work only at a minimum of 10 inches distance from the eyes; otherwise a school habit of near working distance is acquired, which to a great extent persists through school life, and is the cause of most of the hygienic troubles of the scholar.

Next to the better ventilation required in most schools the prevention of the formation of the bad habit of holding objects at a less distance than 10 inches is the most important hygienic improvement needed.

On the principles underlying the evil associated with **needlework** and similar fine work in **infant schools** see my remarks on pages 19 to 22.

Much work is done in school involving the continued working of nerve centres already trained, or getting results in which errors are made less apparent by being made less noticeable, or other work having a deceptive appearance of accuracy which may be grouped as "spurious result" work.

All fine sewing is to be condemned as uneducational. Map-drawing with crow quill pens and fine name-printing are equally bad ; drawing by young children in small squared copy books or on squared slates is likewise wasteful educationally. Ordinary children like this kind of work because it involves no mental effort, being mainly repetition without intellectual effort.

The younger children who are allowed such work, or even drawing with pen or pencil, learn the bad habit of working near their eyes, and this is also helped by the method of reading as frequently taught the younger children with primers.

It is to be noted that many mentally unsteady individuals of what are known as the "higher degenerate" types do this mechanical work, which gives results without mental efforts, well.

Reading and Writing in Infant Schools.—Reading and writing should be learned, letters first, then their groupings into simple words, from symbols not less than 6 inches long until the child is quite familiar with them. This work in the case of reading, should be entirely distant by means of blackboard or reading frames, a very large print primer being occasionally allowed in the highest class of the infant school to add interest to the lesson.

Writing begins also by the child gaining familiarity with the letter forms by coarse methods, as chalk-drawing on the blackboard. Every child in a six-year old class ought to be able to come at once from its place, take a piece of chalk and print its name in letters 6 inches long on the blackboard. Unfortunately, few can do so. Sand trays, pieces of string, or thick malleable wire to bend into shape, shells to lay down, or pieces of stick, are all useful adjuncts to teaching the conventional signs to very young children.

Such children should have free-arm work, being made to stand well back from the board, and should be set to draw things as they see them from the first.

It cannot be too strongly insisted that *needles, pens, pencils and paper are all out of place in the infant school*, that they cause over-pressure and aid the development of bad school habits, only got rid of by much re-education in the upper departments ; for instance, an infant learning to write with pen or pencil, in its efforts to concentrate muscle work, invariably bends the forefinger, so that there is an acute angle in it. No infant scholar will learn to hold a pen in any other way, for the physiological reason that it is the easiest way for him. Inasmuch, however, as it throws all the work on a few fine muscles, it is a bad method for general use, and therefore has to be unlearned in Standards I. or II.

School Windows.—The arrangements for lighting are given on p. 206. It should be remembered also that the windows act for half the year as coolers of the air, which, while hot and foul from respiration, rises to be cooled, unless it has been extracted or driven out of the room by artificial means. Then, unless a gangway is interposed between the window and the desks, the nearest children have to sit with a cold draught of impure air falling on their heads and necks. Mechanical ventilation thus becomes a necessity in schools which are to be sufficiently lighted for educational requirements (see p. 242).

Translucent ground or ribbed glass in any form, which gives hazy or indefinite images, should be avoided owing to its unsatisfactory mental effects. The glare of an unfocussed bright light falling over a considerable part of the retina anywhere near its yellow spot has decidedly exhausting effects, and may produce headaches. The fatigue is less marked when the light falls more obliquely. Children reading or working with a bright light behind them, apart from shadows falling on their work, are liable to be exceedingly irritated by flare spots from irregular reflection on their books, if the incidence of the light on the surface is nearly vertical. Windows on which the sun shines early or late should be provided with blinds of some lightly coloured material.

Roof-lights give exceedingly good diffuse illumination, but are not allowed by the regulations of the Code (page 300). They have the fault that snow obscures, rain, or more especially melting snow, finds leaks, and unless whitewashed in summer sunshine they may make the room unpleasantly hot.

Artificial Lighting.—The fact that artificial illumination varies in brightness inversely as the square of the distance from the light, indicates the desirability of numerous well-distributed lights. The best means for this is single electric lamps, not clustered in electroliers. The steady light of the incandescent gas mantle requires to be well distributed by ribbed globes; the holophane globe does this well. It should be raised above the level of the pupil's visual field, or its glare may be harmful.

Test of School Lighting.—For scientific purposes photometers may be necessary, but for ordinary school life the ability of a normal eye to read diamond print at 16 inches distance in any place may be taken as a satisfactory test of the illumination. The minimum allowable illumination for the darkest place in a room should be under any circumstances ability to read this type at 1 foot. The test used by one large School Board is the ability to distinguish a line of square dots of 1 millimetre square, with an interval between each also of 1 millimetre square, as separate dots, from a distance of 10 feet. It is a good test.

School Walls.—To aid in illumination and avoid loss from absorption, everything in the classroom should be as light in colour as possible; shiny surfaces and flare spots being avoided.

For the sake of a cleanly and tidy appearance walls should not be left in rough brick or stone painted, but should be finished smoothly in plaster and distempered or painted. Woodwork should be lightly painted, avoiding dark staining.

It is generally held that the colours used should approximate to the green or yellow tints of the spectrum, the blues giving a subjective impression of coldness; too much red, on the other hand, not being restful, besides involving loss of much (yellow and green) useful light.

For writing in schools, chalk on dark surfaces is the most convenient, the surfaces used on walls are generally papier maché or a composition.

Blackboards, etc.—In classrooms for infants, and in any of the special schoolrooms for defective or deaf children, plenty of blackboard space is required round the room, the composition being most suitable. Slate is used where abundant locally, and tablets of ground glass with black background are also used. A ledge at the bottom to retain dust is necessary.

Where many children are drawing in desks with chalk, wooden blackened boards are best, but cardboard is frequently used on account of cheapness. It is advisable to have it blackened. In rubbing out, the smallest dusters possible — 6 inches square —

should be provided, or the children will make the atmosphere very dusty, causing dry, irritable throats especially to the teachers.

In young children the transition from blackboard and free-arm drawing to writing should come naturally, by setting them to draw first at the desks ; and then printing and writing, along with the drawing, will be introduced a little at a time.

Lessons in Boys' and Girls' Schools.—Finely ruled copying or small squared drawing books have already been condemned. The child who has been taught the mastery of individual letters correctly does not require very much teaching of writing.

Writing lessons should not be continuous, but frequently broken up ; the pens being put down and the children standing up for exercise, either simple arm movements, or the children being brought out of their places, marched round and then into places again, if fatigue and bad work are to be avoided.

In their mechanical drawing and working with scales, also in working with fine maps, boys are in the greatest danger of maintaining the near work distance, although many do it also in writing. Girls automatically drop into their strained infantile position in sewing. The material used is sometimes very bad. All dark coloured material or thread is injurious. The London School Board prohibits the use of red material. Sometimes spuriously neat work is got by using figured patterns for patching and coloured thread, so that in the work of quite young children the patch is felt but not seen.

Type of Books.—With English type the only troubles likely to arise are from fine type, from the lines being too long, and insufficiently leaded, and from the paper being finished with a glossy surface. The *type* should be clear and large, and the construction of such letters as *h* and *b*, *v* and *n* should be especially precise.

The following words represent well-known sizes of type :—

Double Pica.	*Great Primer.*	*Pica.*
No type	smaller than	Pica should

Small Pica.	*Bourgeois.*	*Minion.*	*Pearl.*	*Brilliant.*
be used	while	teaching	children	to read.

Cohn proposes that the type of ordinary journals should be 4 mm. or $\frac{1}{6}$ inch in height, though M. Javal thinks it may be allowed to be 2 mm. The thickness of down and up-strokes, the spaces between letters and words and between lines, and the length of lines all require attention.

Letter-press derived from a *worn-out fount* gives an imperfect impression of the letters. The loops of *a* and *e*, of *b*, *d*, *p*, *g* are apt to form a black spot ; long letters become broken, and fine up-strokes are imperceptible.

Books for children should not be large or heavy, the spaces between the letters and between words and lines should be relatively wide, and the lines not too long. The actual character of most school books, except in infant schools, is such that this matter is almost trifling. In Germany the Gothic type is one of the serious school errors requiring reformation.

Practically all books are printed on white or yellow toned papers, giving good contrast. Tinted papers with neutral tints spoiling the contrast are bad. Writing ink is often very bad. When supplied in powder form the mixing is sometimes done badly at school. Fluid ink should be supplied to schools, and it should never be watered. Pale ink, or ink which turns black after a time, should be abolished from school.

It is important that too small a handwriting should not be allowed, and that neither writing nor reading should be permitted in the dim light of evening.

The letters on many maps in schools are most trying to the eyes, the lettering not only being fine, but the maps having often been printed from old and worn plates. Maps should contain as few data as possible, teaching by wall-maps and outline-maps being preferable. In writing lessons, the character of the writing material used is of some importance, especially on dull winter days. Thus the farthest distance at which a specimen of slate-pencil writing was recognisable, as compared with a specimen of lead-pencil writing of the same size, was as 7 to 8, while the ratio of lead-pencil to pen and ink legibility was 7 to 8, and of slate writing to pen and ink 3 to 4. The bearing of this on the hygiene of the eye is evident; pen and ink writing should be used where possible.

Desks and Seats.—Desks and seats are described in Chapter XXVI., page 282. It is to be remembered that a seat which will remain uniformly comfortable is an impossibility in school. If a child in the first half of school life is expected to maintain a constant position, he cannot do so, as the muscles get tired very speedily. Any considerable effect is not to be expected from slight variations in the dimensions of seats and desks. If general size and arrangements are approximately correct, details are mere matters of taste. The harm from seats mostly affects certain children who are themselves initially at fault; the want of resistance due to ill-health, which is at the bottom of their troubles, requires most attention, as it also tends to harmful developments visually. The most carefully adapted single seats and desks will, however, have their potential value diminished when used by a class that has already learned the near working habit.

Habit Spasm of Eyes.—In many cases where a fine muscle is habitually overtaxed a condition of nervous irritability and want of control is set up in the nerve centres, resulting in what are termed "functional paralyses" or "habit spasms" from the mixture of spasmodic action and almost paralytic weakness displayed. Telegraphist's cramp, pianoforte player's cramp, writer's cramp are well known examples of such occupation diseases. The occupation disease of the scholar may be said to be spasm of the eye accommodation. The eyes habitually used at too close a distance at last have the nervous mechanism of the ciliary muscle thrown into such a state of irritability that on attempting to fix the gaze on a distant object the habitual contraction of the ciliary muscle comes into play and the eye is accommodated to its usual near use. Although the eye may be quite normal as regards its dimensions, yet from the long sustained near work, and the accommodation having got adapted to this, it cannot be relaxed sufficiently for distant vision, so that the scholar sees distant objects badly and appears to be shortsighted, seeing near things well. Associated with this condition there is often some congestion and irritability of the eye set up which draws attention to it, and the fact of distant vision being bad often accentuates the child's complaints.

Temporary suffering from this condition is common, especially in finely textured children of the nervous type, and most often in girls over eleven years of age. Such children are sometimes taken to sight-testing establishments presided over by the "certificated optician," who generally in such cases prescribes weak concave glasses. These improve the distant vision for a time, but ultimately aggravate the condition, until in bad cases work continued for more than a few minutes may be impossible. From such cases also permanent shortsightedness often develops.

Tests of Vision.—For testing children's vision a series of graduated letters on a test card is used. In the cards in general use (Snellen's Test Types[1]) the top letter should be read at 60 metres, it is marked in small outlined letters, D = 60. The second row, 36 metres ; third, 24 ; fourth, 18 ; fifth, 12 ; sixth, 9 ; and seventh, 6. The child to be tested stands 20 feet (= 6 metres) in front of the card, which is hung in a good light. He ought to be able to read all the letters correctly with either eye, such a result being recorded as $V = \frac{6}{6}$. The numerator expressing the distance in metres at which the child stands, and the denominator the distance at which the smallest letter distinguished ought to be read. If with the right eye the child had only read the first three lines, it would have been recorded $R. V = \frac{6}{24}$. Any fraction less than unity denoting defective visual acuity.

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[1] In the Appendix a sheet of Snellen's Test Types is given. This may be fixed on a board, and is then ready for use.

In testing a long series of children it is found that girls present a greater percentage with defect than boys, and younger children than older children up to the age of eleven, when the conditions are reversed. It is found that country children attain their maximum visual acuity, as a rule, much sooner than town children. On the other hand, if all the children in a certain standard only be taken, the younger the child in its standard the greater its visual acuity as a rule.

Statistics of Eyesight of School Children.—So far vision in ordinary school children only has been dealt with, and the strain which improperly applied tasks throw on them has been pointed out. It seems almost strange that in spite of all these imposed strains the majority come through school life with their vision not a bit the worse, save that possibly their finer visual judgments as regards distance and distant objects have been allowed to remain undeveloped. There remain a considerable proportion who from some inherent weakness, whether nutritional, structural or nervous, are unable to pass the strain of continual eye-work unscathed, or who have suffered by the scars and marks of disease. What these numbers are it is difficult to say ; but taking the best group, boys between the age of ten and twelve, it may be taken that 10 per cent. fall short of normal vision. Other groups exceed this, so that Mr. Brudenell Carter some years ago, from examination of several thousand London children, stated that at least two-thirds of the eyes tested fell short of normal.

There is reason to suppose that the personal equation of the child obtruded itself in these statistics, and that the group was largely made up of young children. Statistics regarding school children in the mass, whether applied to vision or any other personal condition, are worth little for comparison unless arranged in groups according to age and sex.

In the Bradford Board Schools 39,118 children were examined as to their acuteness of vision, by means of test cards containing standard letters, each scholar filling in on a piece of paper all the letters on the card which they could distinguish clearly. The results are shown in Fig. 7. As the number of children in each standard varied from 503 in the Ex. VII. and 2,194 in the 1st to 7,553 in the 3rd standard, the basis of facts on which the following percentages of defective vision are framed is sufficiently large to be trustworthy :—

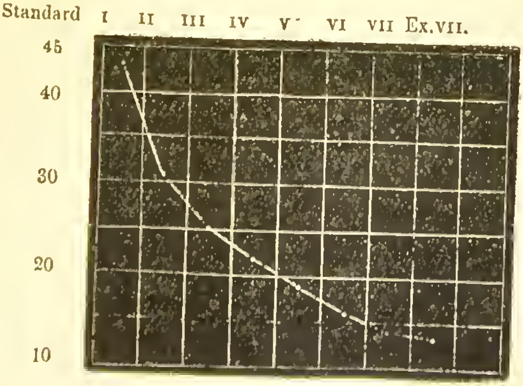

FIG. 7.—Percentage in each standard with defective visual acuity. 39,118 children in standards. (Bradford School Board.)

In another set of observations in which 7,755 girls and 7,787 boys were examined, and classified according to age, the results shown in Fig. 8 were obtained :—

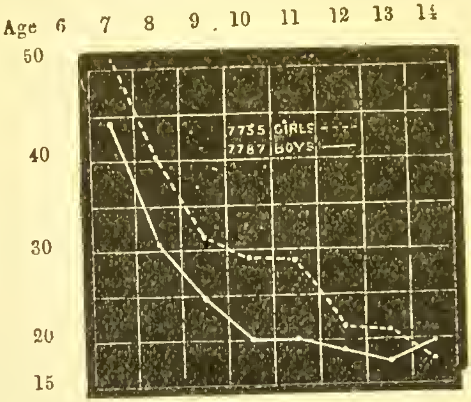

FIG. 8.—Percentage with defective visual acuity at various ages.

Treatment of Sore Eyes.—Defective children in regard to vision comprise a considerable number who have suffered damage from inflammation of the cornea. Many children of low resisting power are prone to slight inflammatory attacks ; the children who from any cause strain the eyes are more liable than others, the eyes feel burning and hot at times, there is a little "matter" in the corner, they may be bloodshot in the mornings, or the lids may be stuck together on waking by dried exudation ; and the little crusts which this forms at the roots of the eyelashes cause irritation, and chronically inflamed thickened edges ultimately develop on the lids, an inflammatory condition called *blepharitis.* It is chiefly seen in unhealthy children, who require much fresh air and cod-liver oil, but also in healthy children, who being longer sighted than usual have the eyes irritated and congested by constant strain.

For these chronic conditions, and for almost all slight inflammatory conditions about the eyes, a useful treatment is to bathe the eyes well with a lotion composed of as much powdered boracic acid as will lie on a shilling dissolved in a pint of tepid water; and at bedtime the lower lid should be pulled down and a piece of ointment the size of a split pea laid on its inner surface to dissolve during the night.

The advice on the cards given to children found defective in the London Board Schools is: "You are cautioned against the grave risks children may incur by wearing glasses as prescribed by the various sight-testing establishments, certified opticians, chemists, toy shops, or any other than qualified medical men.

"In most cases of pustular eye inflammation, irritable or sore eyelids in delicate children, a piece of the following ointment, the size of a lentil, in each eye at bedtime will be found of benefit. Any chemist will supply it, of the following composition: Powdered yellow oxide of mercury, 3 grains, lanolin, 2 drams, vaseline to half an ounce."

The above treatment may only give temporary relief if there is eye-strain, and the use of proper glasses may be necessary if permanent relief is to be obtained.

Formerly much bad eyesight was due to the results of small-pox. The practice of vaccination has materially diminished this, and now serious eye defects are chiefly due to disease in the new-born infant, from want of proper supervision during the first week of life, or later in life from haziness of the cornea caused by inherited constitutional disease. Mere colds and catarrhs, especially in children who are mouth breathers, cause opacities of the cornea, which are very slowly recovered from, and which for months or even a year or two may materially diminish the visual acuity. Small pustules from catarrh occur on the corneal margin, and are often very tedious in delicate children. They may cause dread of light, in which case the child should not be attending school. They do well when treated with the ointment recommended above.

Contagious eye diseases are more particularly seen in the unexercised low-resisting tissues of institution reared children. They are rare in ordinary elementary schools. Rarely an acute inflammation of the eyes may occur in which the eyes are red and watery, then swell and matter for several days, and after this slowly recover. The disease is contagious among the younger children, and sometimes spreads through the household from which the child comes.

A large number of children suffer from poor vision owing to defects in the structural dimensions of the eye. Such defects are called errors of refraction.

Errors of Refraction.—The eye has been described as developing from a flattened mass of tissue, which, growing at unequal rates, results in its globular form. This should be such that when the full-grown eye is at rest parallel rays coming from distant objects are focussed on the retina. Under certain circumstances, which may be the result of differing conditions, as temporary illness, or overuse at different times, or many other conditions affecting nutrition and growth, the development of the eye in one direction or another may be modified.

Long-sightedness or Hypermetropia.—The development of the eye may tend to be arrested or hindered. People in whom the structures of the head seem to develop unevenly, who, for instance, have long faces and narrow, highly arched palates, frequently have squint, commonly a result of hypermetropia. Their eyes have remained in the infantile condition with their optical axes relatively short, *i.e.*, the eye is shorter from behind forward than usual.

Such long-sighted people, like the normally somewhat hypermetropic child, can only see distant objects by exerting accommodation. When not accommodating,.distant rays of light (R, Fig. 9) are brought to a focus at F behind the retina, and a convex lens L is needed to ensure clear vision. The young child with long-sightedness has great power of accommodation for distant objects; but in older people this diminishes, and convex glasses have to be worn, especially for near work. Even in children, if the hypermetropia is so great that there is any difficulty in seeing well, or any suffering from congestive troubles about the eyes, or red margined lids, the question of wearing glasses either constantly or for near work is worth consideration. *If there is any doubt as to whether convex glasses should be worn it is best to wear them*, especially for near work.

Short-sightedness or Myopia.—In other cases either from debility or lack of resisting power in the tissues, after illness, in children of fine texture, and, as a rule, in people with broad heads, there is a tendency to over-development, and stretching of the globe. The axis of the eye becomes relatively too long. This development is normal up to about the fifteenth, but is often continued till the twentieth or twenty-fifth year, after which elongation of the optic axis may be regarded as disease.

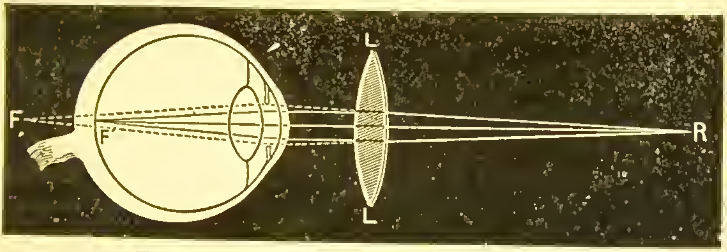

FIG. 9.—Section of hypermetropic eye.

R, the origin of divergent rays of light; F, the focus beyond the eyeball; LL, convex glasses to be worn by hypermetrope; F′, the focus of rays of light on retina, showing influence of L.

This physiological lengthening of the axis may be exaggerated by continued work with objects held near the eyes. The constant tension and sometimes spasm of the ciliary muscle tend to pull the front parts of the choroid and retina forwards; the pressure of the external muscles strongly converging and pressing on the globes tends to squeeze the comparatively unsupported posterior wall backwards ; while at the same time the usual bent attitude of the head tends to general congestion and softness of the structures, so that in many cases such work produces a certain degree of stretching of the globe, with lengthening of the optic axis. Consequently, rays tend to be focussed in front of the retina, and unless an object is brought within a certain distance of the eye it cannot be seen well. Many such cases in children are unreal, due only to spasm, and a warning about the dangers of oculists' and opticians' prescriptions for such cases has already been given (page 101). When there is actual lengthening of the optic axis the condition is called myopia.

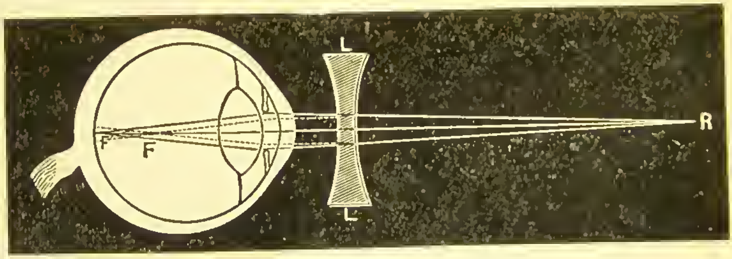

Fig. 10.—Section of myopic eye.

R, the origin of divergent rays of light ; F, the focus of these in front of retina ; LL, concave lens to be worn by myope ; F′, focus of rays of light on retina, showing influence of L.

Myopia exists in another form which is due either to disease or congenital weakness of the eye. This steadily gets worse till in middle life, from the retina becoming detached or hæmorrhage occurring, blindness may result. This malignant myopia, common in Germany, is decidedly uncommon in England. These cases of " High Myopia " occur in quite young children, and progress rapidly during school life.

Such children should not be permitted to do any fine eye work, and it is doubtful whether they should learn to read and write in the ordinary way.

Myopia is relieved by concave glasses, which render the parallel rays from distant objects so divergent that they appear as if coming from the farthest point at which the eye can see things clearly (Fig. 10). *If there is any doubt about wearing concave glasses it is better to do without*, and they should never be worn except after medical prescription.

The majority of children called short-sighted at school are not myopic. They may be hypermetropic or more probably belong to a large class who are astigmatic.

Astigmatism.—In astigmatism the growth of the eye has been so irregular that if a vertical equatorial section were made, it would not be circular, but elliptical. The long axis of the ellipse is usually horizontal, but it may be at any angle with the vertical. Such condition of irregular growth is known as astigmatism. According to the relation of length of the axis of the eye to the axis of this elliptical section the eye may for rays in different planes be hypermetropic, emmetropic or myopic, *i.e.*, long-sighted, normal or near-sighted, or any two of these conditions may be combined. Such people cannot see a point clearly, it appears as a hazy or starred blur, drawn out in one direction. All eyes present this condition in a slight degree if submitted to a sufficiently fine test. To this cause the points of light in the heavens owe their name of stars.

In cases where the astigmatism is not very great, or when there is not much hypermetropia or myopia with it, a certain amount of correction is possible by the lens being strained by just a few fibres of the ciliary muscle contracting in one direction, and no evil effects are felt. In other cases, from constant or near work, this accommodative strain may set up severe nerve symptoms, pain, inability to use the eyes, headaches or neuralgia, which may be constant or more commonly intermitting but frequent.

Astigmatism requires correction in most cases. No optician or spectacle vendor, certificated or otherwise, should be allowed to prescribe the cylindrical glasses generally required for its correction, especially in the case of children. Symptoms are often only partially relieved, sometimes much aggravated by their prescriptions, and the desirability of wearing them and the strength required is entirely a question for the medical man.

The school hygiene of vision may be concluded and summed up in the following extract from Article 147 of the London School Board Code for Teachers :—

"It is exceedingly important that children should, as far as is possible, be prevented from acquiring the bad habit of working with a short distance from eye to work. In no case should any child be permitted to occupy itself with work nearer to the eye than a foot distance.

"In Infants' Departments, in Girls' when sewing, in Boys' when writing, or doing fine work or painting, they often bring their eyes down closely to their work, ensuring cramped chests, round backs, and much eye-strain. During such work teachers should pay especial attention to prevent these habits, and endeavour to secure observance of a proper working distance."

CHAPTER VIII.

PHYSICAL EDUCATION.

ALTHOUGH the term **physical training** is commonly used as if it were synonymous with muscular training, it is in fact much more comprehensive. It embraces all the physiological functions of the body and all the recreative part of life. Hence it is concerned with sedentary games, the reading of light literature, the encouragement of pleasant conversation, etc., as well as with outdoor games and gymnastics. It is concerned with the training of each child in regular habits as regards eating, drinking, sleeping, and the functions of the excretory organs, and with every other means by which the child's health may be brought up to a high standard and maintained at this standard throughout school life. These objects ought to be as much the teacher's object as the instillation of definite knowledge; and the teacher ought to be in a position to send his pupil forth from the school with at least as good health as he possessed on entering it. Many of the above aspects of physical training are discussed in the chapters on "Physiology," "Age and Sex," "The School Programme," "Rest and Sleep," and "Diet". In this chapter special attention is devoted to the influence of the muscles on health.

The muscles represent rather more than half the whole weight of the body; they contain in their substance about one-fourth of the whole volume of blood; and they have an active influence on the circulation of the blood, on respiration and on nutrition, besides being the chief producers of heat in the body. Most of the muscles of the body, being controlled by the will of the individual, are in direct communication with the nervous system, the nervous and muscular systems being both influenced by muscular activity. Thus muscular exercise is important during school life because of its influence (1) on the general health, and (2) on the brain.

1. Influence of Muscular Exercise on the General Health.—The muscles themselves can only be made and kept firm, large and strong by regular exercise. Muscular work is the chief source of heat in the body; the circulation of blood is improved and rendered more uniform, and consequently cold feet and chilblains are avoided. The lungs work more actively during muscular exercise, so as to supply the increased amount of oxygen required. Thus the respiratory capacity is increased, the tendency to a flat-chested condition is averted, and the liability to chest ailments is greatly diminished. The improved nutrition is shown by the better appetite and the improved digestion which are caused by exercise. Indigestion and allied troubles chiefly occur in persons of sedentary occupation.

The following tables from Maclaren's *Physical Education* show some measurable effects of systematic gymnastic exercises. The first table shows the effect of seven and a half months' training of men varying in age from nineteen to twenty-eight, the average age being twenty-four, and the men having been irregularly selected.

	Weight.	Chest girth.	Girth of fore-arm.	Girth of upper-arm.
	lb.	in.	in.	in.
The smallest gain . . .	5	1	$\frac{1}{4}$	1
The largest gain . . .	16	5	$1\frac{1}{4}$	$1\frac{3}{4}$
The average gain . . .	10	$2\frac{7}{8}$	$\frac{3}{4}$	$1\frac{3}{4}$

The second table shows the effect on two articled pupils, aged sixteen and twenty, of a year's steady practice in gymnastic exercises.

In the year's work the increase was—

	Height.	Weight.	Chest.	Fore-arm.	Upper-arm.
	in.	lb.	in.	in.	in.
With the younger .	2	21	5	2	2
With the elder . .	$\frac{3}{8}$	$8\frac{1}{2}$	6	$1\frac{1}{4}$	$1\frac{1}{2}$

2. Influence of Muscular Exercise on the Brain.—During the period of school life the brain and muscles are both undergoing growth and development. They cannot be separated from one another, being intimately in communication by means of nerves. The musculature of the body is doubly represented in the brain; on the surface of the motor convolutions there are centres corresponding to the several muscles of the body, and here arise all voluntary impulses resulting in muscular exercise; these impulses are however under the control of certain sensory convolutions wherein are stored the memories of sensations derived from past muscular contractions giving ideas of weight, distance and resistance. These extensive regions of the brain are in intimate communication with all the other regions of the brain, and at the same time it can attain its full vigour only when the whole muscular system is in a well-developed and healthy condition. It is a well-known fact that each nervous centre requires external stimuli to develop its potential power. If a number of chickens are hatched on a carpet they will run about without attempting to scratch until a little gravel is scattered upon it. The congenital absence of the left hand and atrophy of the left arm have been found after death to be associated with an imperfectly developed condition of the convolution of the brain, in which movements of the hand originate. But where death has occurred some years after amputation of the limb of an adult no alteration in the corresponding part of the brain has been found. Hence the greater importance of exercise before twenty than after that age.

The above considerations render it evident that the development of a considerable portion of the brain is dependent on muscular exercise, and the non-recognition of this principle has been saved from calamitous results in the past only by the instinctive revelling of children in movements of every kind.

The preceding general considerations show the importance of **physical education.** Education, as we have seen, has a much wider meaning than the mere acquiring of a given amount of information. The bodily and mental functions are closely interdependent, and the harmonious working of the two can only be secured by training which is devoted to the muscular system and the special senses, as well as to the intellectual powers. This principle is now recognised in the Code of Instruction for Elementary Schools, which recognises as part of the school curriculum and allows a portion of the school time to be apportioned to instruction in

Manual Instruction ;
Suitable Physical Exercises, *e.g.*, Swimming, Gymnastics, Swedish Drill ;
Military Drill, Cottage Gardening (for boys) ;
Practical Cookery, Laundry Work, Dairy Work, Practical Housewifery (for girls).

One of the most pronounced characteristics of young children is their desire for change, the irrepressible need for movement. Forced inactivity leads to injurious postures, and if continued may cause stooping shoulders, a flat and narrow chest and incipient spinal curvature. Apart from their utility in preventing bad postures and actual deformities, physical exercises as a school subject are a great aid in the maintenance of school discipline, partly by satisfying the natural need for activity and partly by inculcating habits of ready obedience and attention.[1] They furthermore give that rest and diversion from direct intellectual toil which is necessary to secure the best results from such toil. In infant schools a musical accompaniment to the exercises is desirable. For boys military drill is a valuable supplement to the ordinary physical exercises, teaching them a regular and orderly step, and accustoming them to grouped action and to discipline. Swimming forms an excellent form of educational physical education. The Swedish system of gymnastics is the one now most taught in English schools. Paragraph 29 of *Instructions to His Majesty's Inspectors* (1900-1) states :—

> Instruction in Swedish or other drill, or in suitable physical exercises, is a condition of the higher grant for discipline and organisation. Military drill for boys has been found very attractive in certain districts, and deserves encouragement. A healthy game, which is one of the best forms of physical exercise, will satisfy the conditions of the Code. . . . In most town schools, however, even in those which possess large play-yards, such games are impossible, or possible only for a few scholars. The physical development of the frames of growing boys and girls imperatively requires, therefore, in such cases, some form of drill and gymnastics, and it becomes incumbent on teachers to make themselves familiar with those exercises that are best suited to develop a healthy frame without undue strain upon the scholar. Such courses based upon the Swedish or upon the English system are already in use in many schools, but the bad habit of performing exercises while standing upon the school benches should be discouraged. You should also observe whether the drill is conducted under the conditions of sufficient space and a plentiful supply of fresh air. Half-time scholars should not be subjected to any system of exercise or drill which, if practised in the morning, might render them unfit for their afternoon's labour, or, if practised in the afternoon, might press heavily on a tired boy or girl. Children who have walked long distances should also be excused.

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[1] "Physical Education," by George White, B.A., *Transactions of Seventh International Congress on Hygiene and Demog.*, vol. iv., p. 3.

Incapacity for "Training" in Young Children.—The main point to remember is that in elementary schools the aim is not to produce excessive muscular development, but to bring all the functions into greater activity. For this reason the use of apparatus is to be deprecated. For adolescents and adults such apparatus is valuable, as in them the muscles will "train," *i.e.*, will increase in size and harden under the influence of systematic exercises. As pointed out by Mr. C. Roberts, children under twelve or thirteen cannot be trained like older boys either for athletic sports or severe gymnastic exercises. For these reasons "football, cricket and athletic contests, running, etc., do not meet the requirements of young children". In virtue of the fact that their muscles do not train, "the physical work done is the day's supply of energy, and not the accumulated energy and adaptiveness of muscle associated with training; hence football soon exhausts young children, and is too violent while it lasts to be of permanent advantage. The same objection applies to all forms of violent exercise in the gymnasium or elsewhere; hence small children enjoy playing games and are more benefited by them than by athletics or gymnastics with apparatus. There are, however, many gymnastic exercises with light dumb-bells, bars and clubs suitable for young children of both sexes, and they are frequently taught in schools."

Much can be done by the teacher to favour physical education by the encouragement, and, if necessary, the enforcement of good postures in both sitting and standing during school hours. The provision of proper desks and seats is considered later (page 282). Even these may not prevent bad postures, though they tend to do so, and personal supervision is still desirable. It must be remembered that "sitting still" so long at a time is unnatural in childhood, and that the degree of erectness of the spine in adult life is determined largely by the postures taken in school hours.

Bad postures in sitting may occur even at hygienic desks when confinement has been too protracted. It is for this, among other reasons, that intervals of standing and of exercises are so desirable. Among bad postures the two most important are (*a*) the posture in which the pupil slips low down and forward on his seat so that an unsupported length of trunk is left between the shoulder-blades and the seat; and (*b*) the posture in which the pupil stoops over his desk with his left fore-arm resting on it. In the first posture the head droops downward, the chest is constricted, and free respiration impeded; and if the posture is regularly indulged in, the muscles of the back become permanently relaxed and the pupil is round-shouldered with his head leaning forward. In the second posture not only is respiration impeded, and a round-shouldered condition produced as above, but near-sightedness tends to be produced. In the **best posture while sitting** the pelvis forming the seat bones rests equally on the seat, the head is poised almost vertically above the spinal column, the latter is erect, and both arms are equally distant from the spinal column. This posture is less fatiguing than one in which the head is thrown forward, and in which the muscles of the nape of the neck must constantly be exerted to prevent the head falling further forward under the influence of gravity. A few minutes interval during the lessons of each hour for combined drill exercises is an admirable antidote to the evil effects of prolonged sitting, often in a bad position.

Bad postures in standing are common in school life. They should be at once corrected by the teacher, who cannot be too observant on this point. A common evil posture is one in which the weight of the body being on the right foot, and the left foot somewhat in advance of its fellow, the left hip is lowered, and the spine and the pelvis bent to the left, while the head is bent to the right. In this position a line joining the two hips will not be horizontal. Such a position tends to displacement of internal organs.

The **best posture in standing** is with the heels so placed that neither is in advance of the other, and the weight of the body is supported on both legs, and the pelvis and trunk are untwisted. In this position it is easy to stand with the head well poised and the chest thrown forward. The muscles of both legs are, however, subject simultaneously in this posture to the same amount of muscular tension; and when the pupil is required to stand more than a few minutes he should be instructed to secure the muscular relief which is desired by placing one foot in advance of the other, alternating the two feet. It will indirectly repay the teacher to devote time to securing correct postures both in sitting and standing, as better educational results can thus be secured, and the scholars prevented from forming habits inimical to health.

Singing, speaking and reading aloud are most valuable in strengthening the throat and lungs, and rendering them less prone to disease (see also page 58).

Forms of Exercise.—Outside the school the question of physical education is concerned with free play, organised games and formal gymnastics.

If there is one point more important than another it is that exercise should be as varied as possible. The spontaneous activity of children is more conducive to general strength and healthy brain-growth than any formal gymnastics. The latter can never form a complete substitute for games. The movements are more rigid and less varied, and consequently sooner produce fatigue, and the competition which serves for a stimulus in gymnastics is a very poor substitute for the enjoyment accompanying varied play. The enjoyable mental excitement of games accelerates the circulation and helps all the bodily functions.

The more purely recreative physical exercise is, the greater the relief from school work. The difficulty of providing playgrounds of sufficient size is, in this connection, unfortunate. When this is unavoidable, gymnastics should be resorted to.

Running, leaping, rowing, swimming, cricket, racquets, tennis, etc., have all their place, and are deservedly popular. Boating should be restricted to those who can swim. Football, properly regulated, is a valuable exercise, and not less valuable as a means of cultivating rapid self-control under circumstances of mental excitement.

Rules for Exercise.—In taking exercise the following rules should be followed. The clothing should allow free play of the limbs, and expansion of the chest, flannel or woollen being always worn next the skin. A belt should never be worn round the waist, as a " rupture " may be caused by this means. Chill, which is so often produced by sitting in a draught after perspiration, must be carefully avoided. The exercise must be systematic and regular, never sudden and violent, and the amount of exercise must be regulated by individual fitness. Every part of the body must be exercised. Exercise must not be taken directly after meals.

Exercise should as far as possible be taken in the open air. The fact that the amount of air inspired during exercise is greatly increased serves to emphasise this rule, and explains why the benefit of girls' calisthenics is greatly diminished by their being commonly taken indoors.

CHAPTER IX.

REST AND SLEEP.

LIFE is made up of alternations of rest and action. Exercise of any organ of the body is followed by a necessary period of repose, during which effete matters are carried by the blood to the excretory organs, and fresh nutritive material is supplied by the same fluid.

The only apparent exceptions are the heart and lungs, and these in reality obey the universal law, the only difference being that their rest is frequent and momentary, while that of other organs is at greater intervals and of longer duration.

The heart, for instance, contracts about once every second, but in the intervals of each contraction it rests $\frac{6}{11}$ of a second, or over thirteen hours in the day.

The necessity for rest can be easily proved in the case of the sense of taste. If salt be kept in the mouth for a considerable time, the power of tasting it disappears, and only returns in its original strength after several hours. The temporary deafness from the noise of machinery, and the fact that after looking at a given colour for some time only its complementary colour is visible, are other instances of the same law.

Rest may be partial or general.

Partial rest is obtained by change of occupation, bringing into play the activity of other organs.

The importance of varying school work at frequent intervals, thus exercising different parts of the brain, has been already discussed (see page 53). Similarly in the last chapter we have emphasised the importance of recreative muscular exercise. By these two means undue pressure of school work may nearly always be prevented. Repose is not gained by change of occupation requiring attention, but by being released from attention.

Sleep is the only form of complete and general rest. During sleep a diminished amount of blood flows through the brain, and the functional activity of its higher centres is abrogated. If a boy or girl eats and sleeps well, the brain is almost certainly not being over-worked. On the contrary, when there has been excessive mental work the effects of this cannot be entirely compensated by prolonging sleep. The mental work must be diminished, and more time must also be allowed for recreation.

The amount of sleep required varies according to age, and to some extent according to personal idiosyncrasy. As a rule, the following daily amounts are required at various ages :—

4	years old,	12	hours.
7	,,	11	,,
9	,,	10½	,,
12-14	,,	9-10	,,
14-21	,,	9	,,

Children under fourteen should be allowed a little more sleep in winter than in summer, and when growing very fast. Punctuality in the time of sleep is of great importance, owing to the habit acquired. Great drowsiness or wakefulness in children should receive medical investigation. The night screamings to which some children are subject may be associated with overwork at school, but they usually occur apart from school work in children of a very nervous temperament.

The regulation of children's sleep is a matter which chiefly lies with parents, and they may greatly help the school teacher by attention to it. Growing boys and girls are, especially in winter, too often taken to concerts or other evening meetings. In view of the commonly foul atmosphere of these public rooms, it is not surprising that they appear next morning at school with dark rings about their eyes, and generally incapacitated for mental application.

The importance of sleeping in a pure atmosphere, and of having, during winter, a flannel jacket or other warm covering to the arms and shoulders, need only be referred to.

School Dormitories of boarding schools should never be used during the day for study or other purposes. The windows should be kept widely open during the day in order to ensure a thorough and prolonged sweep of fresh air through the rooms. Open bedrooms if not too large are usually preferable to separate cubicles, as they can be more thoroughly ventilated and the pupils better supervised.

The same rules for ventilation and warming apply as for schoolrooms. As the pupil passes about one-third of each day in his bedroom, its atmosphere should be as pure as possible. Even with the best means of ventilation this cannot be secured, unless a sufficient floor-space is allowed for each pupil. Beds are frequently placed almost, or quite, in contact, and such overcrowding occurs as, if it happened in a common lodging-house, would lead to the prosecution of the landlord. We shall see (page 222) that not less than 3,000 cubic feet of fresh air are required by each pupil per hour. But if the air is changed more than three or four times per hour, violent draughts are produced. It follows, therefore, that from 750 to 1,000 cubic feet of space should be allowed for each scholar in the bedroom, and preferably the latter amount. Ventilating openings do not obviate the necessity for this amount of space, as children (like their seniors) will close up any orifice from which an unpleasant draught is perceptible. Dr. Dukes, the physician to

Rugby School, urges that taking a school-bed at 3 by 6 feet, the superficial area of the bedroom should be 6 by 12 feet per pupil, and the room 12 feet high. This gives 864 cubic feet per head, which, allowing for the air displaced by the furniture of the room and the boy himself, leaves about 800 cubic feet per head. Poor health and anæmia in scholars at boarding schools are favoured by crowded bedrooms, as well as by insufficient or inferior food, and overwork.

Each pupil should have his own towel, brush and comb, and wash-basin. The interchange of these frequently leads to the spread of ringworm, or contagious affections of the eye. Small towels, to be used on one occasion only, and then set aside for washing, are the most efficient means of preventing the spread of contagion.

CHAPTER X.

CHILDREN'S DIET.

Food and Growth.—The diet of children should be generous and abundant.

There is no danger of giving too much food, if only simple and wholesome dishes are allowed. After forty it may be broadly said that the chief danger in regard to diet is of over-feeding, under twenty of under-feeding. It must be remembered that during youth, and up to the age of twenty-five, physiological processes are much more active than at a later period; freer exercise is usually taken, and, in addition, food is required not only to supply energy for carrying on the functions of the body, but also for purposes of growth. Children have to make new tissues as well as to keep in repair those already formed. Also as their bodies expose more surface, in proportion to bulk, than adults, they require a proportionately larger amount of food to compensate for loss of heat.

It is, in the main, only after waste of tissues and loss of heat have been provided for that any surplus of nutriment goes to the further growth of the body. If the food supply is scanty, one of two things must happen: growth will be impeded, and children will be stunted specimens of humanity; or some of the organs of the body, as the brain, or muscles, or bone will suffer in functional activity and may eventually become the seat of actual disease.

The younger an animal, the more easily is it starved; and the more actively growing are its organs, the more seriously are they injured by partial starvation ; and the same applies to human beings.

Apart from the food required for growth and development the close relationship between **food and work** must be remembered in the case of children as well as of the adult. Work can no more be done by a child without food than by a steam-engine without fuel. The more brain work a child does, the more food he requires. It is a great fallacy to suppose that food is less necessary for the brain worker than for the navvy. Each metabolises (roughly speaking—oxidises) a large amount of combustible material, which must be supplied by food. The navvy, however, commonly assimilates his combustible material with greater ease than the brain worker, owing to his better digestion.

Under-feeding.—The practice of giving **penny dinners** to children of Board Schools in poor districts has been introduced on a considerable scale. A still better plan would be to give them a mug of milk and slice of bread before the morning's work begins. If there is no other means of ensuring that these children shall receive sufficient food, this practice is most commendable, for although half-starved children may with an effort succeed in their studies, it is at the expense of a diminutive stature and feeble muscles. We cannot agree, however, that they are, apart from these special meals, more unfavourably situated than they would be if allowed to run about the streets.

The children even of wealthy people are often underfed, a certain amount being apportioned at each meal, and further helpings refused. We hold that a healthy child's appetite is the best guide as to the amount of food required, so long as the food is plain and wholesome. He may surfeit himself with rich pastry or cakes, but seldom with porridge and milk.

The danger of under-feeding is greater among girls. Until recent years a good appetite was often regarded by them as something to be ashamed of. Happily this view is now rare. Girls between the ages of fourteen and twenty often suffer from a species of chronic starvation, having got into the habit of relying on bread and butter and puddings, to the almost complete exclusion of meat, or other nitrogenous food. Much weakness and ill-health in after life are ascribable to this cause.

According to De Chaumont, for a child weighing 100 lb. (who would probably be fifteen years old, see chart, page 32) about 3 oz. of proteid or nitrogenous food, 2½ oz. of fat, 12 oz. of carbohydrates (starch and sugar), and about ¾ oz. of mineral matter are required per diem. In order to obtain the above amount of proteid material 6 oz. of meat would be required unless cheese, legumens (beans, peas, etc.), or milk are freely taken. It may be convenient to remember that bread contains about 8 per cent. proteid and 50 per cent. starch, meat 15 per cent. proteid, cheese over 30 per cent., and peas and beans generally 22 per cent. Most dietaries contain abundance of starch and sugar, but are deficient in fat. This deficiency is a most important matter. If children will not eat the fat of meat, dripping, butter, and suet puddings are very useful.

The importance of *sufficient fat* in food can scarcely be exaggerated. Deficiency of cream in the cow's milk with which infants are commonly fed, owing to the admixture of separated with whole milk, is an important factor in producing **Rickets**. This disease not only causes bone deformities, but also "damages the brain power of the population, with its consequent neurotic conditions".—(Warner.)

Children's diet should be varied and palatable. The intervals between meals should be regular and not too long. The food should not be allowed to be bolted, but carefully chewed. Milk should form an important part of all children's diet. Alcohol should not be given in any form, unless under medical responsibility. The teeth should be carefully supervised ; overcrowding of the permanent teeth should be prevented by the dentist's aid, and caries should receive early attention.

In **Boarding Schools** the head teacher must consider the possibility of infectious diseases being introduced by means of food, especially by milk. Epidemics of scarlet fever, diphtheria and typhoid fever have been repeatedly traced to infected milk. Tubercular infection may also be conveyed by milk. Boiling milk offers an efficient means of preventing these dangers; and the temperature of 68° to 70° C. ("pasteurising") continued for thirty minutes destroys the acute infections named above. If the source of supply is certified by the medical officer of health and by a veterinary surgeon, who has applied the "tuberculin" test to the cows, to be above suspicion, these precautions so far as tuberculosis is concerned are generally unnecessary.

CHAPTER XI.

CHILDREN'S DRESS.

Physiology of Dress.—A certain temperature of the surface of the body (about 98·5 Fahr.) is necessary for the maintenance of health, and from this it never varies more than 1°. This temperature is the result of the chemical processes going on in the body, the fuel for which is supplied by the food taken. Food being deficient, the body-temperature would necessarily fall if there were no reserve of combustible material stored up in the tissues.

It is evident that heat may be economised, and thus within certain limits the amount of food required may be diminished by preventing some of the loss of heat from the body. About 80 to 90 per cent. of this loss being by the skin, clothing plays an important part in preventing loss of heat.

Clothing should prevent as far as possible radiation and conduction of heat, but should not prevent evaporation of the perspiration. The material which is in these respects best, both for summer and winter wear, is wool, which should always be worn next the skin; the thickness, and not the material, being altered according to the external temperature.

Amount of Clothing.—The amount of clothing for children should be sufficient to prevent any sensation of cold. Excessive clothing may increase the tendency to catch cold, by exciting perspiration, and because the extra clothing is often thrown off at irregular intervals. The effect of wearing a thick scarf round the neck is a well-known instance of this.

A deficient amount of clothing is even more dangerous. The attempt is commonly made to "harden" children to bear exposure to cold with bare arms and legs even when not engaged in active exercise. The consequences of this hardening theory are calamitous; not a few children are hardened out of the world, and those who survive are apt to suffer permanently, either in growth or constitution. The dwarfishness of Laplanders and Esquimaux is an illustration of this principle. Children produce heat less freely, and lose it more quickly, than adults, hence the great mortality of children in cold climates during the winter months.

Liebig first clearly explained the importance of clothing, saying: "Our clothing is, in reference to the temperature of the body, merely an equivalent for a certain amount of food". It will be easily understood, therefore, how deficient clothing, like deficient food, may produce stunted growth, or lay the foundation for disease, or bring latent disease into activity.

Distribution of Clothing. — Children's clothing should be of such a character that the warmth is uniformly distributed. No extra amount of chest protection will prevent bronchitis or pneumonia if the legs and feet are cold. The adoption of leggings and sleeves for young children should always be insisted on. *Thin boots* are especially objectionable. There is a great sympathy between the feet and the respiratory tract. Sore throat is frequently due to cold and damp feet. The boots should be thick enough to keep the feet dry and warm.

Damp garments should be laid aside at once on reaching home, and the teacher should never allow a scholar to remain in school with wet clothes.

The practice of wearing thicker outside garments while in the warm schoolroom is very objectionable. The skin becomes relaxed and perspiration occurs, and the subsequent exposure on the journey home renders a severe catarrh probable.

The clothing should not be changed according to the calendar, but according to the state of the weather.

The wearing of summer clothing late into autumn, and the assuming of light outer-garments and underclothing as soon as a fine day in spring appears, are dangerous for children.

Moist cold is a good conductor of heat, and the damp chilliness of an early November requires as warm and thick clothing as the dry, clear cold of January.

Tight clothing of any kind should be avoided. It interferes with free movement and so prevents proper exercise. All clothing should be slung from the shoulder, not tied round the waist.

Tight corsets are particularly objectionable, or belts round the waist. Tight sleeves and skirts prevent free movements of the limbs. Stockings should be supported by suspenders and not by garters. Tight boots destroy the natural elasticity of the movements, besides interfering with the circulation and thus causing cold feet. High-heeled boots produce an uncertain and ungraceful gait in girls; they throw the weight of the body on the front part of the feet, disturbing its balance, and tending to produce spinal curvature. The soles of shoes should be broader than the feet, the heels low and broad, and the soles should be thick enough to keep out all damp. Sandals are preferable to boots for active exercise.

CHAPTER XII.

BATHS AND BATHING.

In previous chapters the use of food and clothing in preventing loss of heat and maintaining a uniform temperature has been briefly discussed. In this chapter we wish briefly to impress the fact that the skin, by the proper use of water, may be brought into such a robust condition that the sudden alternations of temperature to which children are necessarily exposed, become comparatively free from danger.

No school education is complete which does not teach children the necessity for a clean skin. A dirty condition of the person strongly favours the occurrence of infectious disease, besides helping to produce that unpleasant odour which commonly belongs to the air of a schoolroom full of scholars.

With a dirty skin the cutaneous blood-vessels become deficient in tone, and the production of chills is thus favoured. If morning cold baths are not well borne by children, wet sponging followed by friction with a dry rough towel forms a good substitute.

It is impossible, even if it were desirable, always to keep children in warm rooms. They play about in cold corridors, or other places exposed to cold currents of air, and if their skin is lacking in tone, a sore throat or bronchitis may be the result.

School Bathing is very desirable, though arrangements are seldom made for it. Schools containing several hundred boys cannot be regarded as complete unless they possess a swimming-bath of their own, or one accessible to them. Many unfortunate accidents would be prevented, and much gain to the health and happiness of children would result if they were taught to swim. A boy accustomed to plunge into cold water (*i.e.*, at 50° to 60°, not 32°) is much less likely to suffer from exposure to the ordinary alternations of temperature than other children, and, if by chance he should get wet through, is less liable to be chilled and suffer from catarrh or bronchitis.

Swimming combines the advantages of bathing and exercise. A plunge into running water is more liable to produce cramp, or dangerous chilling of vital organs, than a plunge into the water of a swimming-bath, as, in the former case, the water around the swimmer is constantly being changed, and so a greater abstraction of heat from the body occurs.

School bathing should always be under strict supervision. Children should not be allowed to loiter in undressing; they should never be allowed to remain in the water until chattering of teeth, or blueness of lips or nails, is produced; and the bath should not be taken within two hours of a meal.

CHAPTER XIII.

SCHOOL ACCIDENTS.

THE extreme utility of "First Aid" to the injured is shown by the popularity which the St. John's Ambulance lectures have attained. To teachers, the knowledge of "First Aid" is particularly useful, for, in addition to the numerous accidents that occur in connection with school games, scholars may occasionally have fits or faints, or hæmorrhage. Panic, the result of ignorance, and even injury to health and limb, might often be prevented by the application of the simple rules of treatment which will be laid down in this chapter.

It must not be supposed that we are encouraging teachers to take upon themselves the sole treatment of serious cases, although we may have to describe the treatment of such cases in detail. But valuable time is frequently lost before a medical man arrives, and it is therefore highly important that the teacher should know what to do in the interval. Hence a not unsuitable heading for this chapter would be—"Until the doctor comes".

Fainting in schools which are ill-ventilated and over-heated is not infrequent. The patient should be laid on his back, with his head low; all tight clothing should be removed from his neck; crowding round him should be avoided, and, if possible, he should be placed in a free current of air, near an open door. Do not attempt to pour anything down the throat while the patient remains unconscious, or the patient may be choked.

Fits may occur in school. In boys' schools, epileptic fits occur ; in girls' schools, hysterical fits may also occur.

In epilepsy, during the convulsions, the patient should be laid gently on the floor, and prevented from biting his tongue, by inserting a cork between his teeth. All tight clothing should be removed, and no further attempt at active treatment made.

In hysteria, as a rule, the patient is not quite unconscious ; she sobs considerably, and is evidently in a highly emotional condition. She will not allow the ball of her eye to be touched with the finger without flinching, unlike an epileptic patient. Hysterical patients should be removed from the school as soon as possible, as an example of this kind is likely to be copied. Their morbid condition should not be fed by over-attention or indulgence.

Suffocation is occasionally imminent from a marble or cherry stone, or similar substance, being held in the mouth, and then suddenly sucked down into the larynx. Such an accident is always serious, and a doctor should be immediately called, the messenger being instructed to tell him the nature of the accident in order that no time may be lost. In the meantime, the only safe measure is to put the finger to the back of the throat, in the hope that the foreign body may be reached. Even if it is not reached, vomiting is commonly excited, and this may dislodge it. The child should not be inverted until the doctor arrives, as, if it is not successful, the symptoms may be aggravated.

Apparent Drowning is not an infrequent accident, especially in country districts during half-holidays, and the teacher should instruct his scholars as to the plan to be followed in such an emergency.

The apparently-drowned boy should be placed on the bank, his mouth cleansed from mud, etc., and his tongue drawn forward out of the mouth. It is seized by the fingers in which a handkerchief is held to prevent the tongue slipping back. A folded coat should be placed under his head and shoulders, so as to give firm support. Next, the boy's arms should be grasped near the elbows by the operator, who stands over the boy, facing towards his feet. The arms should be drawn over the boy's head, and then pressed down firmly against the sides of his chest. This manipulation should be repeated regularly about fifteen times a minute, taking care not to perform the movements hurriedly. The upward movement expands the chest, while the pressure of the arms on the chest causes expulsion of air from it. In this way inspiration and expiration are imitated, and the natural process of respiration may in favourable cases be restored.

At the same time, other persons should secure warm and dry blankets and hot bottles, and should rub the legs steadily, so as to help the circulation and keep up the temperature of the body. The artificial respiration is, however, the most important point, and should not be intermitted until natural attempts at breathing occur, or until half an hour has elapsed without sign of recovery.

Foreign Bodies are occasionally pushed by enterprising children into the ear or nostril. In the latter case they can usually be seen and seized by a pair of tweezers, or hooked down by a fine wire hoop. In the former case simple syringing with warm water will frequently wash out the foreign matter. If it is a pea syringing is better omitted, as the pea may swell and thus become more firmly impacted.

Minute particles of dust, etc., frequently set up great irritation in the eye. Try and invert the upper eyelid, and then the speck can usually be seen, and removed with the corner of a pocket-handkerchief. If it cannot be seen, drop a little castor-oil into the eye, keep the eye closed and immobile by means of a wet compress over it, and, if relief is not obtained in a few hours, seek further advice.

If a needle becomes imbedded under the skin, the affected part should be kept fixed, and a surgeon seen. Thorns and splinters may usually be removed by cutting through the top skin (epidermis) with a sharp and clean knife, and then seizing the fragment with a pair of tweezers. If the splinter is under the finger-nail, its removal is much more difficult, and the teacher will seldom have skill or courage to cut down the nail, as is sometimes necessary.

The **Stings** of bees and wasps are best relieved by first bathing with hot water and squeezing out the poison, and then applying a strong solution of bicarbonate of soda to the affected parts. The same treatment holds good for nettle-stings.

The **Bite** of a dog is not in itself serious, unless the dog is mad. As, however, the latter fact cannot at once be ascertained, it is wise to adopt the necessary precautions in every case. The wound should be bathed with hot water and thoroughly sponged. It is also desirable to increase bleeding from the wound by enlarging it with a sharp pocket-knife. Lunar caustic is of little service, but as most schools have some strong nitric acid on the premises, this should be carefully applied to the wound by means of a penholder dipped in the acid, the surrounding parts of the skin being protected against the corrosive action of the acid.

Wounds of varying degree and severity are very apt to occur in connection with school life. The wounded part should be laid bare, and the wound thoroughly washed with cold water, in order to remove any grit or other foreign matter that may have entered it. Then the edges should be brought as near together as possible, and a pad of linen moistened with cold water should be applied by means of a bandage. The patient should be placed in such a position that the edges of the wound will not be strained ; thus, if the wound is on the cheek, speaking and chewing should be avoided ;

if on the leg, walking must not be allowed. Punctured wounds, from knives, etc., may be very serious, and in all doubtful cases a medical man should be sent for.

Abrasions, in which the skin is rubbed off, are best treated by washing carefully with cold water, and then applying some Friar's balsam or collodion. For wounds and abrasions, sticking-plaster should never be applied alone. It nearly always sets up irritation and causes the wound to suppurate.

Swollen Glands are apt to occur after a wound or whitlow, or other injury. Thus, a swelling under the armpit may occur from a poisoned finger. Such a condition requires careful attention, rather to the cause of the enlarged glands, than to the glands themselves. Enlarged glands in the neck are not infrequently due to lice in the head, or a discharge from the ears, or sore eyes, or eczema on the head or face. Given that these conditions are removed, the enlarged glands disappear, unless some disorder of the general health coexists.

Hæmorrhage is due to the rupture of a blood-vessel. This may be due to a wound, or may come from the lungs, nose, or other parts, independently of external injury.

Arterial bleeding is the most serious, and is distinguished from venous or capillary bleeding by its greater amount, by the bright scarlet colour of the blood, and by the fact that it comes out in intermittent jets, corresponding to the beats of the heart.

Venous or capillary bleeding can always be controlled by placing a linen pad on the wound, and firmly bandaging it in its place.

To control arterial bleeding the same measure is usually successful, only the pad must be made firm and hard, and tightly bound in its place. If a main artery is divided, as shown by the great spurting of blood, a firm pad may be held firmly pressed by the two thumbs over the wound until further aid can be obtained. If the teacher knows the course of the main blood-vessels in the limb, he may stop the hæmorrhage by pressing his thumb over the main artery higher up the limb; but as a rule, he will probably be more successful by trusting to a firm pad kept forcibly pressed over the wound itself.

An elevated position of the limb will help to stop bleeding from it, and a flexed position of the joint next above the wounded part has a similar effect. Thus, with a severe wound in the palm of the hand, apply a pad firmly over the wound, bend the elbow, and keep the whole arm raised.

If coughing or vomiting of blood occurs, keep the patient perfectly quiet, and give nothing except ice to suck, and obtain medical aid at once. In bleeding from the nose, apply iced compresses to the nape of the neck, and syringe the nose out with iced water. If this does not answer, put some alum or tannin in the water to be injected into the nostril. If the bleeding still continues, a powder containing 30 grains of bromide of potassium may be given in water, and repeated in half an hour, if necessary. This seldom fails to stop the hæmorrhage.

Burns are apt to occur in connection with open fires or hot-water pipes. The best immediate application is probably a linen cloth soaked in a saturated solution of bicarbonate of soda, which very quickly relieves the pain and burning.

The following injuries are most apt to occur in connection with football, though occasionally from cricket or in the gymnasium :—

Fractures are recognised by inability to use the affected limb, shortening and alteration in its shape, and a crackling sound when an attempt is made to move it. There is no urgency about treating a broken limb before the arrival of a surgeon. If it is necessary, however, to remove the patient indoors, the limb should first be secured in splints, and he should be carried on an improvised stretcher. Splints may be improvised by taking long pieces of a box-lid, or an umbrella; or for children, brown paper folded up so as to be stiff and rigid.

Dislocations are liable to be confused with fractures, but the limb is more fixed than in fracture, and there is no crackling sound on movement. The fact that the injury is obviously near a joint helps to a diagnosis, though sometimes fractures may occur close to a joint. Any attempt at replacing the dislocated bone by an unskilled person is dangerous.

Sprains are best treated by bandaging immediately, and applying spirit and water, or some other cold evaporating lotion. The part should be kept immobile, and the after-treatment requires great care.

Contusions, as from a kick on the shin or a blow in the eye, result in the escape of blood under the skin (as in a "black eye"). The extravasation of blood may be minimised, and its absorption helped by a cold evaporating lotion.

More serious accidents occasionally happen in cricket and football. In cricket, a fatal result has occasionally followed a blow behind the ear by the cricket-ball. It is difficult to suggest precautions that would prevent the possibility of this accident.

In football, a blow or kick over the abdomen or chest may cause sudden death, or, short of this, complete collapse, which in some cases requires several weeks before complete recovery occurs.

In lawn-tennis, the right elbow is sometimes peculiarly injured. This is now well recognised under the name of "tennis-arm". It is due to injury of certain ligaments, or a small muscle near the elbow-joint. The only remedy is abstinence from the game for a prolonged period.

Football has the unenviable reputation of being the pastime which is, far above all others, liable to be accompanied by serious or even fatal accidents. Scarcely a week passes in the football season without several accidents being recorded in the newspapers. It is only fair, however, that their number should be considered in relation to the enormous number of persons who play the game ; and thus stated, the game must be considered as one to be commended. "For every one who may have been harmed by football a thousand have benefited by it. Health, endurance, courage, judgment, and above all, a sense of fair play are gained upon the football field. A footballer must learn, and does learn, to play fairly in the thick and heat of a struggle. Such qualities are those which make a nation brave and great."[1]

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[1] Mr. Shearman, "Badminton Library Volume" ; quoted by Sir F. Treves, Stevenson and Murphy's *Hygiene*, vol. i., p. 606.

CHAPTER XIV.

ACUTE INFECTIOUS DISEASES IN SCHOOL LIFE.

ACUTE infectious diseases are very important, both from the standpoint of those responsible for the public health, and from the teacher's standpoint, because no other diseases so seriously diminish the average school attendance. Happily, the best means which the teacher can employ to bring the average attendance to a maximum are by co-operating, in the manner to be hereafter indicated, with the medical officer of health. It is a fundamental mistake for the former to imagine that he or she will improve the average attendance by hastening the return to school of children suffering, or suspected to be suffering, from slight attacks of illness, or by allowing the attendance at school of children from infected houses. Such children, if they attend school, whether in consequence of the pressure brought to bear upon their parents by the school-attendance officer or the teacher, or in consequence of the carelessness of parents, are the most fertile source of school epidemics; whereas, by co-operation with the medical officer of health, they can be isolated, their attendances can be included by the certificate of that officer in the average attendance (page 154), and grants claimed for them, while no danger to other scholars is incurred.

Infection is Spread by Particulate Matter.—It has been proved for diphtheria and enteric or typhoid fever, and other less-known infectious diseases, and although not yet demonstrated is almost equally certain for such common school complaints as measles, scarlet fever, mumps and chicken-pox, that infection is transmitted from scholar to scholar by minute living particles or *germs*, which are the active agents causing the disease, the germs of each individual disease having special distinctive characters. In other words, these diseases "breed true," the germ of scarlet fever, for instance, not producing measles, or *vice versâ*. These germs may be carried from scholar to scholar by direct contact, as when a girl convalescent from diphtheria kisses another girl, or when mucus from the throat of a child suffering from scarlet fever or whooping cough is coughed into the face of another child. This is called **direct infection** or *contagion*. They may also be carried from scholar to scholar, and frequently are, by **indirect infection**. Thus a lead pencil is sucked by a healthy scholar, who two or three days later develops diphtheria. On inquiry it is found that another scholar had previously sucked the same pencil who had returned to school after a week or two weeks' absence from what was considered to be a "sore throat" or "ulcerated throat". Similarly, sweet-stuffs are not infrequently passed from mouth to mouth. Other common sources of indirect infection arise. Thus, a child sickening with scarlet fever vomits in the schoolroom. Although this is cleaned up, some particles of infective material occasionally remain, become dry, and are then inhaled as dust raised by moving about the room, and give scarlet fever to other children. Or a child attending school from a house in which is a case of scarlet fever, or diphtheria, or whooping cough, may carry in his clothes the infection to other children at school, although he himself remains well. As the essential method of communication of disease is the same in both direct and indirect infection, it is better to avoid the words *contagion* and *contagious* as likely to give rise to the erroneous notion that direct contact with a patient is necessary in order that infection may be transmitted.

To What Extent do Schools Spread Infectious Diseases ?—Each infectious disease we have seen is conveyed by particles of matter given off by the infectious patient, and carried directly from him to the infected child, or indirectly by these infected particles having become attached to the personal apparel of the patient, or to that of healthy children from the same house, or to books or other articles which have previously come into contact with the patient. This particulate matter, containing the living germs of the disease in question, is so minute as to be invisible to the naked eye. It may be finer than the dust that floats in the air of every occupied room, and, like it, can be disturbed and spread about by the active movements occurring in every schoolroom. The smallest particle of dust may contain a large number of germs of disease. These general considerations leave no doubt as to what answer must be given to the above question. It would be more than surprising were the conditions of school life not provocative of a large amount of infectious disease. The intimacy of close personal contact between scholars in the same class, closely massed together, must necessarily give numerous opportunities for the spread of infection. In scarlet fever and diphtheria the infection is located largely in the throat, and such common practices as passing on sweetmeats from mouth to mouth, turning over leaves of books with wetted finger, spitting on slates in connection with their cleansing, etc., need only be mentioned to enable one to realise how commonly disease must be spread in this way, when children with mild " sore throats " are allowed to attend school.

The experience of every medical officer of health teaches him that schools are frequently a centre of infection, and that he can only obtain complete control of a particular epidemic by excluding children from all suspected families, or even by entirely closing a school, or one department of it, in which the cases of infectious disease have occurred. Mr. Shirley Murphy has shown that in London, when allowance is made for the period of incubation of these diseases, there has been during several years a marked fall in the number of cases of diphtheria and scarlet fever notified during the three or four weeks embraced in the August-September summer school holiday; the effect being most marked for cases at ages three to thirteen, the years of school attendance. It is only right in this connection to quote the remarks I have made elsewhere to the following effect:[1] "It is one thing to admit that school attendance, in common with all other means of personal communication between susceptible persons (of whom scholars at elementary schools form a vast majority), is an important factor in determining the extent of the spreading of diphtheria, and another to attempt to explain, as some have done, the recent epidemic of diphtheria in England, as if it were caused chiefly by the increased enforcement of compulsory school attendance. Mr. Murphy is satisfied to show that *school attendance is a means of spread of diphtheria.* With that all must agree, and must further agree as to the urgent necessity for additional precautionary measures in connection with the close aggregation of children in elementary day schools. Others, less judiciously, attempt to explain the entire or the greater part of the recent increase of diphtheria in England as due to school attendance. Such a notion will be corrected by looking at diphtheria from an international standpoint. Notwithstanding its enforcement of compulsory school attendance since 1871, London, even in its maximal epidemic year (1893), presents no more diphtheria in proportion to its population than is constantly endemic in Paris or Berlin."

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[1] *Epidemic Diphtheria: A Research on the Origin and Spread of the Disease from an International Standpoint,* by A. Newsholme (Sonnenschein & Co., 1898, p. 135).

Does any Good Accrue from Keeping Away from School the Healthy Children of Infected Houses?— Most teachers will admit the necessity for isolation of infectious patients. Many, however, deny the necessity for keeping from school the healthy or apparently healthy children from infected houses to the extent to be shortly described. They are supported in the following words from a foreign medical authority: "It seems to me that every assemblage of children facilitates the propagation of diphtheria. It is evidently impossible to prevent children—and especially children of the lower classes—from assembling. If they are not sent to school, they will assemble, all the same, to amuse themselves. In this case there will be no supervision, and there will be greater opportunities for them to infect one another than if they were in a school. . . . Of all the opportunities that children have of assembling together, that which school affords them appears to me the least dangerous."

I have quoted these words in full so that the case for their contention may be stated as strongly as possible. They do not, however, present a true picture of the conditions of school life in this country. A scholar from an infected house, possibly conveying infection in his apparel or in his own throat or skin from an unrecognised attack, does not, particularly in the lower classes, which are chiefly affected, constantly occupy the same seat. He is not always seated next to the same two children throughout the school session. His position may be moved several times in the same day, and he thus has opportunities for distributing infection to children—not only to those who live in the same street, but to others in different parts of a wide district, thus originating fresh foci from which disease can spread. On the other hand, if kept from school he may, notwithstanding directions to the contrary, play with other children in the street or in a neighbour's house. Out of doors the danger of infection is greatly diminished ; indoors it is limited to neighbours, who may already know the possibilities of danger. There can be no reasonable doubt that the risk under the latter circumstances is much more limited and less operative than when the suspected child attends school.

Dangers from Children Attending School while Suffering from an Infectious Disease.—The Legislature has now provided means by which this danger is minimised, so far as each of the chief infectious diseases—such as small-pox, scarlet fever and diphtheria—is concerned. It is made compulsory, both on the parent or guardian and on the medical practitioner, to notify each case to the medical officer of health as soon as they become aware of its existence. In most districts, however, measles, whooping cough, chicken-pox, mumps and other so-called " minor " infectious diseases are not compulsorily notified, and the teacher must take the initiative in preventive measures if the rapid spread of these diseases in school is to be avoided. Even so far as the more serious diseases above-mentioned are concerned, cases frequently escape detection. Scarlet fever and diphtheria, for instance, are sometimes extremely mild in character ; the mother may think a doctor unnecessary, and a week or ten days after the commencement of what was thought to be an innocent sore throat a scholar returns to school in a condition in which he can inflict great mischief on his schoolfellows. For these reasons it is important that every teacher should be familiar with the natural history of these diseases.

Natural History of Infectious Diseases.—When a child receives infection, there first occurs a latent period, or **period of incubation,** in which no symptoms occur, and the patient is not infectious. After a varying interval the patient is seized with the **symptoms of onset.** At this time he may be attending school, and he is capable of spreading disease from the first moment that the symptoms occur. Indeed, contrary to the prevalent idea, such diseases as scarlet fever and diphtheria are usually more intensely infectious in the first three days of the attack than at any later period of the disease.

In **Scarlet Fever**[1] the onset is usually sudden. Vomiting, or what is known as a "bilious attack," very often is the first symptom of scarlet fever. The patient complains of a sore throat, and has a hot, dry skin and a rapid pulse. Within twenty-four hours a red rash appears on the chest, soon becoming a scarlet flush, and spreading all over the body. After a few days, seldom delayed beyond the end of three weeks, the skin "peels" off various parts of the body. On the hands and feet the skin looks ragged. There may be "pin-holes" in these parts, which, along with the ragged appearance, are usually characteristic. In some cases the initial symptoms are very slight. If any scholar is found with rough hands, with discharge from the ear, or with sores about the nostrils, and with a history of a feverish attack or sore throat two or three weeks earlier, he ought to be sent home and a medical inspection required.

The onset of **Diphtheria** is less sudden. The sore throat comes on rather gradually. White patches can usually be seen on the tonsils when the tongue is depressed. It is not necessary that an exact diagnosis should be made, because *every child suffering from sore throat should be regarded as dangerously infectious.* If the glands of the neck below and behind the lower jaw are enlarged, the case is still more suspicious. Diphtheria is unfortunately regarded by the public and often by doctors as being necessarily a disease which must give rise to very serious symptoms; and if a scholar with a sore throat is not very ill with it, this is considered to be good evidence that there is no diphtheria. Nothing could be more fallacious. Diphtheria may be so slight that the patient himself complains but little. Hence the importance of the rule that every sore throat should be regarded as infectious until proved not to be so. In many large towns facilities are provided for the gratuitous bacteriological examination of "swabs" on which a little mucus from the tonsils or other parts of the throat or nose of suspected patients has been taken. This is subsequently spread on solidified blood serum and grown in an incubator at 37° C. for twelve hours, and the growth microscopically examined for the diphtheria-bacillus. Such an examination frequently reveals the presence of diphtheria-bacilli in throats where a doctor would be unable positively to diagnose the disease on the strength of a naked-eye examination. There is little doubt that in the near future this additional aid in keeping diphtheria out of school will be largely utilised.

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[1] Scarlatina is identical with scarlet fever, notwithstanding the common impression that the two names represent different entities.

The late Sir R. Thorne laid stress on the "progressive development of the property of infectivity" of sore throats in connection with the crowding of school life. There is no positive evidence that a mild non-diphtheritic sore throat can thus become converted into diphtheria. But the crowding of school life facilitates the carriage of infection ; and under such conditions of crowding mild diphtheria gradually increases in virulence, and probably also in infectiousness, as it passes from child to child.

It is important to remember that the infection of diphtheria may lurk in the throat, and still more in the nose, of convalescent diphtheria patients, and be capable of being passed on to healthy children, for some weeks, and occasionally even for some months, after all evidence of illness has disappeared. This is particularly apt to occur after those slight attacks which have not been regarded as diphtheria, and in which the appropriate treatment has not been adopted. Cases regarded as "sore throat," a "bad cold," or an "ulcerated throat," may really mean diphtheria. Hence no scholar should be allowed to return to school after any form of sore throat until a medical certificate has been obtained of freedom from infection; and in towns where the means are available, this should not be given until a bacteriological examination of some of the mucus from the patient's throat or nose, or both, has been made. This may necessitate the absence of the infected child from school for a protracted period, sometimes three months, or even longer. In Brighton the rule observed is that a child having had diphtheria is not permitted to resume attendance at school until six weeks have elapsed from the end of the attack, *i.e.*, from the date on which the diphtheria bacillus has not been found on the third of three consecutive bacteriological examinations.

Small-pox may spread in schools when this disease is prevalent in a district. In severe cases the patient is too ill to attend school. The only possibility of school attendance is when a scholar who has been imperfectly vaccinated suffers from an attack of "varioloid," *i.e.*, modified small-pox, in which the only evidence of disease may be the occurrence of a few pimples or pustules, chiefly to be seen on the forehead. Among scholars imperfectly vaccinated or unvaccinated, such a case might cause a serious spread of disease. Every scholar ought to be revaccinated at the age of ten years. This would render a school epidemic of small-pox, and, in fact, an epidemic of small-pox among the general population a practical impossibility.

In **Chicken-pox** there are usually (unlike small-pox) scarcely any premonitory symptoms before the pimples appear. These rapidly become clear vesicles (*i.e.*, minute watery blebs), which dry off or form scabs.

Measles begins with all the symptoms of a bad "cold in the head," causing running at the eyes and nose. At the end of seventy-two hours, red, blotchy spots appear on the face, hands and other parts, rapidly becoming general, the spots often being arranged on the skin in crescentic forms. Influenza and an ordinary "cold" begin in the same way. As both these are extremely infectious, the safe plan is to send home any scholar who is suffering from the symptoms of severe catarrh or "cold," especially if measles is prevalent at the time.

Rötheln, or German Measles, has a rash somewhat similar to that of ordinary measles. This is, however, preceded not by a "cold in the head," but by a sore throat—a fact which has occasionally led to mistakes between this disease and scarlet fever.

Mumps comes on with pain near the ear and enlargement of the parotid salivary gland, which causes a bulging out at the side of the neck and in front of the ear, by which means it can be distinguished from enlargement of glands due to other causes. Occasionally it affects only one side, usually both sides.

Whooping Cough is a disease in which the characteristic "whooping" does not occur for a week or two, but the cough appears to be due simply to bronchial catarrh. The disease, unfortunately, is infectious during this stage. In judging of the character of a cough, the history of other cases of whooping cough may help in the diagnosis. Every teacher should be familiar with the "whoop," which is characteristic of more advanced whooping cough, and send any child home who has it, or who, even without it, has *a cough severe enough to make him vomit.* The characteristic cough is violent and repeated, and is followed by a sudden, noisy crowing in-breathing, known as a "whoop".

The danger from the attendance at school of children suffering from an infectious disease arises chiefly from their attendance at two periods : (*a*) while suffering from the early symptoms, or (*b*) when convalescent from the disease, but still retaining infection in their person or apparel.

To minimise the dangers under the first of these heads the teacher should be familiar with the symptoms of onset of the chief infectious diseases as described above, as by this means he may be enabled to exclude suspicious children. Occasionally the symptoms may not be characteristic. The only safe rule is, when in doubt, act as if the scholar were infectious, particularly when it is known that the disease concerning which suspicion has been excited is prevalent. The following summary of these symptoms, which is sent out from the Brighton Public Health Office with all letters to school teachers, gives a useful summary of what has been already said on the subject :—

Hints as to Infectious Diseases.

As infection is sometimes spread by means of children attending school while suffering from undetected infectious diseases, the following hints may be useful to the teacher :—

1. Any scholar having a sore throat should be sent home, and regarded as infectious until the throat has been examined by a doctor.

   If a scholar has enlarged glands in the neck, and especially if he or she is very pallid, the suspicion of possible diphtheria should be entertained. *Many slight cases of diphtheria escape detection.*

2. Any scholar suffering from a severe cold, with sneezing, redness of the eyes, and running at the nose should be sent home. It may mean an influenza cold or the commencement of measles, and both are infectious. This recommendation is particularly important when measles is known to be prevalent.
3. A child with a violent cough, especially if it is severe enough to cause vomiting or nose-bleeding, should be suspected of whooping cough, and sent home, even if the characteristic "whoop" is not heard.
4. Slight cases of scarlet fever sometimes escape notice, and the

patients are sent to school with the skin on the hands, etc., freely "peeling".

5. In any of the above instances, or any other case of suspicion, the medical officer of health, on receiving a confidential intimation, will be glad to make an investigation.

Under the Infectious Disease (Notification) Act, the medical officer of health receives information as to all known cases of disease coming within the schedule of the Act, including usually scarlet fever, diphtheria, small-pox and typhoid fever. Measles and whooping cough, as well as chicken-pox and mumps, are not in most districts included in the schedule of notifiable diseases. The medical officer of health, on receipt of a notification of any of the above diseases, sends an intimation to the head teacher of the school attended by the patient (if a scholar), or by any scholar who is an occupant of the same house as the patient.

The following form is adopted in Brighton :—

"*Strictly Confidential.*

"TOWN HALL, BRIGHTON,
...., 19...........

"DEAR......................

"...
of...is now ill at the Fever Hospital, or at home, suffering from...................................

"He should not be allowed to return to school for ....days,[1] and during the next......................days no other children from the same house should be allowed to attend school.

"Yours very truly,

"...

"Medical Officer of Health."

---

[1] When the patient is sent home from hospital, or released from isolation at home, a second letter is sent to the head teacher, stating that the ex-patient must not resume school attendance until four further weeks have elapsed for scarlet fever and six weeks for diphtheria.

In London it is compulsory under the Public Health (London) Act, 1891, on the medical officer of health to send this information to the head teacher of the school attended by the patient (if a child), or by any child who is an inmate of the same house as the patient. In all well-regulated provincial districts the same practice is adopted.

Duration of Infection.—It is important to know at what interval after the onset of an infectious disease a child may return to school. This should theoretically coincide with the end of the period of infection; but as it is wise in all cases to allow a margin, we have given the average duration of infection (this must be decided for each individual case by a doctor), and the interval at the end of which return to school may be allowed, in separate columns in the following table. It is assumed that all wearing apparel has been disinfected as well as the room occupied by the child. Occasionally a scholar is taken ill in a particular dress; this escapes disinfection, and the patient is allowed to wear it on returning to school, thus carrying the infection with him.

A scholar who has been suffering from an infectious disease should never be re-admitted to school without a medical certificate of freedom from infection, or an official intimation to the same effect from the medical officer of health. If a doctor's certificate assumes freedom from an infectious disease earlier than is given in Table I., the child should be allowed to attend only after receiving a second medical certificate, or after consultation with the medical officer of health.

Some large School Boards now have their own medical officers to whom such a point would properly be referred. **The admission to school of apparently healthy children from infected houses** is strictly forbidden, especially for measles, scarlet fever and diphtheria, for the following reasons: (*a*) The children thus attending school may be suffering from *an*

TABLE I.

Disease. (1)	Duration of Infection. (2)	Date at which School Attendance may be Resumed. (3)	Duration of Quarantine of Children exposed to Infection. (4)
Scarlet Fever.	From 5 to 8 weeks; occasionally longer; ceases when all peeling of the skin has been completed, and when the child is free from discharge from the nose or ear or from sore places.	Not less than 8 weeks from the beginning of the rash, and then only if he has no sore throat or sore places.[1]	14 days.
Diphtheria.	At least 14 to 21 days; generally longer.	Not less than 6 weeks from the onset of sore throat, and not then if strength not recovered, or if any sore throat or any discharge from nose, eyes, ears, etc. Freedom from infection should have been ascertained by three consecutive bacteriological examinations of "swabs" from the patient's throat.[1]	28 days.
Small-pox and Chicken-pox.	About 4 to 5 weeks.	When every scab has fallen off.	18 days.
Measles.	From 3 to 4 weeks; when all cough and branny shedding of skin have ceased.	Not less than 4 weeks from beginning of rash.	21 days.
Rötheln (German Measles).	From 2 to 3 weeks.	From 3 to 4 weeks from beginning of rash.	21 days.
Mumps.	About 21 days from the beginning.	Four weeks from the beginning.	24 days.
Whooping Cough.	Six weeks from the beginning of whooping, or when the cough has quite ceased.	In about 8 weeks.	21 days.
Typhus and Typhoid Fevers.	Four to 5 weeks.	When sufficiently strong.	28 days.

[1] For footnote see opposite page.

unrecognised attack of the disease at an early or in the convalescent stage. In either case they may be an active source of infection. Children with mild attacks of scarlet fever and diphtheria frequently attend school after only a few days at home, when they may be stated to have had merely a "bad cold" or an "ordinary sore throat".

(*b*) The children from an infected house, although *themselves well, may carry infection* in their clothes, or in their throats, etc. All infectious diseases may be thus conveyed by intermediaries, although the scholar who acts as an intermediary may remain well. It must be remembered that not every child exposed to infection will develop the disease in question. A suitable soil, as well as the specific seed, is necessary; and there is nothing surprising, therefore, in the circumstance that a child may be an active means of spreading infection while remaining himself in good health. In diphtheria this is especially true; persons exposed to infection, although they remain well, may convey diphtheria to others, the bacilli of diphtheria being found in their throat or nose on bacteriological examination. Such persons are called "carrier cases". Such "contacts" or possible "carrier cases" therefore need to be temporarily kept from school and from free contact with other children. It is because of the possibility of the carriage of the infection of diphtheria by children apparently well that we give in Table I. the period of quarantine period for diphtheria as 28 days.

The next question is, **How long is the absence**

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[1] In view of the fact that the infections of both scarlet fever and diphtheria are apt to hang about the throat and nose after all obvious symptoms of the disease have disappeared, we have adopted the following rule, which we believe is not unnecessarily stringent: *For scarlet fever do not allow school attendance for four weeks, and for diphtheria do not allow school attendance for six weeks after the patient is certified by the medical practitioner to be free from infection; i.e.*, for this number of weeks after he has been released from home or hospital isolation.

of healthy children from an infected house to be maintained? The answer to this question will vary according as the infectious patient has or has not been removed to an isolation hospital. If the patient has been removed to an isolation hospital, the house and its infected contents efficiently disinfected, the remaining healthy children in the house may resume school attendance after an interval, which we may call the *quarantine period.* If the patient is treated at home, the other children must be kept from school during the whole period of infection *plus* the quarantine period.

The length of the quarantine period varies with the time which each infectious disease requires to develop, *i.e., with the duration of the period of incubation*, during which the patient may be in fair health, and does not appear to be a source of infection. It may require to be extended as in diphtheria, owing to the possible occurrence of undetected cases.

During this period, a scholar from an infected house might conceivably attend school without risk to others. This cannot, however, be permitted (*a*) because in these early days after the removal to an isolation hospital of the first patient, the brother attending school may carry infection in his clothes; and (*b*) he may while in the classroom develop the first symptoms of the disease and infect other scholars. For these reasons the teacher must never relax rules for particular cases. A fixed time must elapse before return is allowed (see Table I., col. (4)). Furthermore, for similar reasons the period of exclusion must be long enough to embrace the longest known period of incubation of the disease in question, even though in the majority of cases a somewhat earlier return would be unattended with danger.

With the onset of the earliest symptoms a child becomes a centre of infection, even before the characteristic rash has appeared in scarlet fever and measles. The period of incubation of the various fevers is shown in the following table:—

TABLE II.

Disease.	Begins usually on the	But may possibly be at any period between
Scarlet Fever	2nd to 4th day	1 and 7 days
Diphtheria	2nd to 4th ,,	2 ,, 5 ,,
Small-pox	12th ,,	9 ,, 14 ,,
Chicken-pox	14th ,,	10 ,, 18 ,,
Typhus Fever . . .	12th ,,	1 ,, 21 ,,
Typhoid Fever . . .	14th to 21st ,,	1 ,, 24 ,,
Measles	12th to 14th ,,	7 ,, 18 ,,
Rötheln	14th to 18th ,,	8 ,, 20 ,,
Mumps	19th ,,	14 ,, 24 ,,
Whooping Cough . . .	14th ,,	7 ,, 14 ,,

In the last column in Table I., it will be noticed that a period of quarantine is given in each case which is somewhat longer than the period of incubation defined in Table II. This is arranged in order to allow a margin of safety for unforeseen circumstances.

The quarantine period must be assumed to start from the end of the longest possible period of infection of the last person who has been ill *in the house*. Thus, referring to the tables, it will be seen that, after scarlet fever an exposed child must not return to school for eight *plus* two weeks; after mumps, twenty-one *plus* twenty-four days, etc. This may seem an unnecessarily long period, but the only way to avoid possible infection is to adhere rigidly to it where children have remained *in the same house* as infectious patients. Of course, if the healthy children have been removed to another house, or if the patient has been removed to a hospital, and no possible communication is allowed, then only the period of quarantine given in the last column of Table I. need be insisted on.

The question occasionally arises as to whether children of a *second family*, coming from an infected house, may be allowed to attend school. The answer must be that the same rules apply to them as to the brothers and sisters of the patient.

Average Attendance at School in Relation to Preceding Rules.—The teacher of an elementary day school, in which Government grant depends upon average attendance, will not unnaturally look askance at the preceding regulations, especially those restricting the attendance at school of healthy children from infected houses. We have already indicated (page 137) that these regulations are calculated to improve the average attendance, and that the teacher who carries them out most intelligently and strictly will suffer the least from the thinning of his average attendance by infectious diseases. A machinery, however, exists by means of which the average attendance of children thus excluded can be reckoned, and this has been freely utilised in Brighton. As this does not appear to be well known by teachers in most parts of the country, a description of it is reproduced here. Each head teacher of an elementary school is supplied with foolscap forms of which the following is a copy :—

FORM FOR NOTIFICATION OF INFECTIOUS DISEASES TO MEDICAL OFFICER.

(1)	(2)	(3)	(4)	(5)	(6)
Name and Address of Scholar.	Date of last Attendance at School.	Date when Reported to M.O.H.	Date when Scholar may Return to School.[1] (This column to be filled in by M.O.H.)	Supposed Nature of Illness.	Inclusive Dates within which Scholar was Absent from School on account of Notice of Sanitary Authority. (This column to be filled in by M.O.H.)

Signature of Medical Officer of Health.

....

....

Name of School ....

Department ....

Teacher's Signature..

---

[1] This date is subject to no other case of infectious disease arising in the house.

The teacher, as soon as he becomes aware of the absence of a scholar on account of what is suspected to be an infectious ailment, sends the above form to the medical officer of health with columns (1), (2), (3) and (5) filled in. This is always done promptly, because *the advantage* (*in average attendance*) *to the school only commences from the date when the form reaches the medical officer of health.* The absentee scholar is then visited, and on the basis of the information thus received the medical officer of health fills in columns (4) and (6). Chronic contagious complaints like ringworm are included, when a medical certificate is obtained. Mumps and chicken-pox, measles and whooping cough, are signed for as well as the compulsorily notifiable diseases. At the end of the school year application is made to the Board of Education by the School Managers on Form 101,* the entries in this form being checked in the office of the medical officer of health from the forms signed by the latter, which have been carefully preserved by the teacher during the year. The following is the official form for this purpose as used by the Board of Education :—

FLY-LEAF TO FORM 101.*

....School,

....County of..

....

1. What vacations were allowed during the past school year? (Give exact dates.)

2. During what period or periods was the school closed on account of epidemic sickness or for other causes? (Give exact dates.)

....

We certify that the children whose names and addresses are entered in Column I. were excluded from school for the reasons and period stated in Columns II. and III.

(Signed)..

Correspondent for the School Managers.

....

Principal Teacher.

Date..

I.		II.	III.		IV.
Name of Child.	Address.	Authority for Exclusion on ground of Infectious Diseases.†	Period, falling within the School Year, during which child has been excluded from attending School.		Number of Actual Meetings of the School during the period specified in Column III. ‡
			Beginning	Ending	

Form 101* is then countersigned by the medical officer of health, who in addition writes a formal certificate to the effect that—

> The children belonging to ...... School, in the borough
district of ...... who are enumerated in the accompanying list, to each sheet of which I have appended my signature, were excluded from attendance at school by order of the Sanitary Authority of the borough
district of ....

It should be noted that the medical officer of health signs up not only for absences of patients, but also of all other children from infected houses. This fact tends to secure the co-operation of teachers and school attendance officers, and relieves the stress of compulsory school attendance, which, however necessary it may be on educational grounds, is not infrequently the means of spread of infection.

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* See Appendix II., page 309, for more recent regulations.

† Enter in this column S.A., if the child was excluded by Notice of Sanitary Authority; P., if under the requirement of any Act of Parliament; and M.A., if under Medical Advice as to children living in infected houses.

‡ No entry may be made in Column IV. for any period during which the school was closed.

N.B.—The entries for Boys, Girls and Infants respectively must be kept distinct, and the sex of the Infants distinguished.

Several years' experience of the system just described has increased our appreciation of its merits :—

1. It enables the school authorities to obtain credit with the Board of Education, Whitehall, for a large amount of average attendance which would otherwise not be counted.

2. It secures for the medical officer of health more prompt information as to the non-notifiable infectious diseases, measles, whooping cough, mumps, etc., than would otherwise be secured. As medical men are frequently not called in at first for these diseases, this system of notification by school teachers gives valuable information which would not otherwise be forthcoming, and enables him by inquiry in the homes indicated by notification of school cases, to secure information as to other cases in neighbouring houses, and thus take more sweeping measures against the spread of infection than would otherwise be practicable.

3. It secures for the teacher skilled guidance and direction as to the necessary duration of exclusion of children living in infected households.

4. In practice in Brighton the system has been extended to cases of doubtful diagnosis. Thus, if during the prevalence of diphtheria a scholar attends school with a sore throat or enlarged cervical glands, an intimation is sent to the medical officer of health, the scholar is visited at his home, a " swab" taken, and the necessary directions then given to the teacher.

School Closure.—The closing of schools may be required to stay an epidemic when the exclusion of particular children from school has not been successful. The rules governing the exclusion of individual children have been already stated (pages 147 to 156). They do not always succeed, partly because of the limitations of our knowledge, and partly because conscientious action does not always follow when knowledge is possessed. The difficulties as to limitations of knowledge are the most difficult to overcome. Even when a medical practitioner has seen the patient, a mistake is occasionally made. This will be made clear by two examples. The doctor sees a child with sore throat, really indicative of diphtheria, in which no "membrane" can be seen on examining the tonsils. The patient is poor, and the doctor is not asked to see the patient next day, when more obvious symptoms are present. The child rapidly recovers—some cases of diphtheria are so mild that at the end of three or four days all naked-eye signs of disease have disappeared—and in another week may resume attendance at school. The dried nasal discharge on his pocket-handkerchief, his personal apparel, the dust formed by the drying of the saliva with which he has cleaned his slate, are all still extremely infectious—not to speak of the further possibilities connected with kissing, passing sweetmeats from mouth to mouth, or accidental direct infection by spray from the throat during coughing or speaking. Or a child has a red rash, with scarcely any sore throat. A dispensary letter is applied for, but the doctor does not arrive until next day. The rash has now faded, and the doctor, in view of the slightness of the symptoms, comes to the conclusion that the disease is not scarlet fever, or may not even entertain the idea of the possibility of scarlet fever. He omits the precautionary measure to urge isolation until time has been allowed for desquamation of skin to begin, and none has occurred. The child returns to school; at the end of two or three weeks attention is called to the particular school by other cases of scarlet fever among its scholars; and a personal examination by the medical officer of health reveals the fact that this particular child is "peeling," or has such well-known complications of scarlet fever as running at the nose or ear.

The difficulties due to lack of conscientiousness on the part of parents are almost as difficult to overcome. Sometimes their conduct can be better described as ignorant though culpable carelessness. The child was "not bad at all," had only a "slight cold," or "a little sore throat," and slight cases of this kind are the chief cause of spread of disease in school. The teacher should miss no opportunity of emphasising the fact that *the degree of infectiousness is not necessarily proportional to the severity of the case.* It is the slightest cases that are most apt to spread disease. Occasionally the mother conceals facts as to illness in the house, particularly as to measles, sending children to school from a house reeking with infection. It would be easy to multiply examples ; but the sum of the whole matter is that we cannot hope entirely to stop school epidemics until we secure the co-operation of mothers, and this will only be practicable to the full extent when a higher ethical standard of conduct than that holding good at present has become the rule. Could not clergymen and ministers help in this matter? Teachers, again, might advantageously take an occasional opportunity to address their elder children on the subject, giving the gist of the rules and principles which have been laid down in this chapter, and still more emphasising the "golden rule" which ensures regard to these rules and principles.

If parents, teachers and sanitary officials were all equally alert, industrious, intelligent and conscientious, school closure would seldom if ever be required. School closure is, in fact, an admission of failure to deal with an outbreak of infectious disease in detail. This failure arises from conditions partly controllable, partly uncontrollable. School closure is the substitution, *faut de mieux*, of a wholesale undiscriminating exclusion of school children for individual and discriminating exclusion. The responsibility for this failure must be divided between the sanitary authorities, the school teachers and the parents. The relative share of these three varies in different instances ; but in adjudging of the responsibility of the sanitary authorities it must be borne in mind that most infectious diseases are *spread by infection from child to child*, and that evil conditions of drains, etc., occupy a minor place in the matter. It is important that these should receive attention ; but it is contact between healthy children and sick children or children from infected houses that is the chief cause of the spread of disease. It is clear, therefore, that parents must be held primarily responsible, and that teachers can reduce their responsibility to *nil* by furnishing the medical officer of health with the returns described on page 154.

Article 88 of the *Code of Regulations for Day Schools* prescribes the conditions under which school closure can be enforced. It states :—

> " The managers must at once comply with any notice of the sanitary authority of the district in which the school is situated, or any two members thereof acting on the advice of the medical officer of health, requiring them for a specified time, with a view to preventing the spread of disease, or any danger to health likely to arise from the condition of the school, either to close the school or to exclude any scholars from attendance ; but after complying they may appeal to the Department if they consider the notice to be unreasonable ".

This notice gives power either to close the entire school or to exclude particular scholars from attendance. The latter subject, and the methods of obtaining grant for children thus excluded, have been discussed on pages 154 to 157. The power to close a school is given to any two members of the sanitary authority acting on the advice of the medical officer of health. This is to ensure promptitude of action ; which is further insured by the fact that any appeal against the closing order to the Board of Education must be made *after* the notice is complied with.

The conditions requiring closure of a school are clearly indicated in the above-quoted article of the *Education Code:* (*a*) A serious amount of infectious disease in the school; (*b*) an insanitary condition of the school. The latter is the simpler case, and may be taken first. If the drains are choked, the closets in a foul and defective condition, and still more if the underground drain on examination is found to be leaky, thus involving the danger of effluvia of a noxious character escaping into the schoolrooms, or into the lavatories and closets used by the children, the school should be closed while the necessary work is being executed. Where the condition is such as to admit of delay, structural works should always be carried out during the long vacations.

The following rule is laid down in a Memorandum by the Local Government Board as to closing schools on account of an epidemic :—

> "*As to the Closing of Schools.*—This, by more seriously interfering with the educational work of a district, is a much more grave step for a sanitary authority to take than to direct the exclusion of particular scholars. It is a measure that seldom ought to be enforced, except in presence of an actual epidemic, nor even then as a matter of routine, nor unless there be a clear prospect of preventing the propagation of disease, such as could not be looked for from less comprehensive action.
>
> "The mere fact that in an epidemic many of the sufferers are school children does not necessarily show that the disease was caught at school; but the school may with probability be regarded as spreading infection if in a large majority of households attacked the first case be a child attending school, and with still

greater probability if a number of children living at a distance from one another, and with no circumstances in common, except that they attend the same school, should be simultaneously attacked, and if it can be ascertained that a child or teacher in an infectious state has actually been attending the school."

The two following considerations are given in the same Memorandum:—

"In deciding whether an outbreak of infectious disease among children of school age may be best combated by closing the school, or whether it will suffice to exclude the children of infected households, the two most important points to be considered are:—

"(*a*) The completeness and promptness of the information received by the officers of the sanitary authority respecting the occurrence of infectious cases.

"(*b*) The opportunities which exist for intercourse between the children of different households elsewhere than at school."

The Infectious Disease (Notification) Act is now in force in every part of Great Britain, and if in addition the teacher gives all possible information to the medical officer of health, the conditions named under (*a*) are fulfilled, and the necessity for school closure should be exceptional.

Sunday Schools.—Under (*b*) the question of preventing "school treats" and preventing attendance for an equal period at Sunday schools requires consideration. There is no legal power in these instances. Usually those responsible for Sunday schools will close them when requested to do so, but this is not universally true. It is obvious that the full benefit of day school closure cannot be secured if the same children continue to attend Sunday school. Sunday schools, furthermore, owing to denominational considerations, often represent a wider constituency than day schools, and may thus be the means of spreading infection over a wider area. Still, even if the closure of Sunday schools cannot be secured, it does not follow that day-school closure should not be enforced. For, in the first place, the possibilities of personal communication on a large scale are reduced to at least one-sixth, probably much more than this. Only a small proportion of those attending day schools attend Sunday schools, and the children attending Sunday schools are in a larger proportion older and therefore less susceptible to infection than those attending day schools. In the second place, the chief cause of "failure of carefully considered measures of exclusion to stay the spread of an epidemic which shows a special incidence upon school children" may thus be eliminated, as such a failure commonly points to the continued attendance at school of children with the prevalent disease in a mild or unrecognised form. Such children are less likely to be sent to a Sunday than to a day school. Our experience has been that children attending Sunday schools have a higher average age, that they are much fewer in number, and that their influence in spreading infectious diseases is very small as compared with that of day schools.

Day Schools.—School closure is usually much more effective in checking the spread of disease in sparsely populated rural districts than in towns. In the former, the children of different households or of separate hamlets rarely meet except at or on their way to the village school. But although this is true, it still remains a sound rule that by closing a school in a town we remove the chief means of intimate intercourse between children on a large scale, and do great good, even though we cannot entirely prevent other forms of intercourse.

Occasionally it is also desirable to *close a school for measures of purification and disinfection* when a number of cases of infectious disease have occurred in it. Too much importance is attached by the laity to disinfection. Unlimited faith is placed in sprinkling carbolic powder or sanitas, or even in exposing trays containing Condy's fluid in the room. All these are almost or entirely useless. They are even harmful, as they divert attention from the really important matters. If a dust-bin or a water-closet or urinal emits a foul odour, the proper remedy is not the application of disinfectants, but the thorough scrubbing and cleansing of the malodorous apparatus, and the substitution of an efficient for a defective apparatus. If books have been handled by infected patients, they are preferably burned. If serious objection is taken to this, they may be effectively disinfected by steam under pressure in a steam disinfector such as is now possessed by many urban sanitary authorities. This ruins leather covers; but cardboard or cloth covers are but little damaged, beyond some curling of edges, etc. (see page 293). Slates should be thoroughly washed. Desks should be scrubbed out, and every part of the walls and floors also washed. The best disinfectant is soap and water, effectually applied to every square inch of the schoolroom. The germs of disease, when submerged in soapy water, are harmless, if poured down the drain. It is chiefly as dust, scattered about the room by every movement, that they are potent for ill.

To sum up: school closure is indicated (1) if measures of exclusion of individual children have failed to prevent the continued and increasing spread of an infectious disease among school children; the number of cases of this disease being in excess of the incidence of the same disease in the rest of the district, and of the number of cases among the children attending other schools; (2) if, by reason of the absence or exclusion of a large number of children, the attendance at school is greatly reduced. This is particularly apt to happen in epidemics of measles, and then the managers not infrequently request that the school may be closed by order of the sanitary authority.

School Closure for Measles and Diphtheria.—The question of school closure most often arises in connection with measles and diphtheria. In scarlet fever it is seldom required, as this disease usually spreads slowly in schools, and careful elimination of individual families generally suffices. In measles, however, owing to its very early infectivity, possibly for three days before the characteristic rash appears, and in diphtheria owing to its occurrence in school children in unrecognised forms and its protracted infectivity, and owing to the occurrence of "contact" cases, it may occasionally happen that nothing short of school closure suffices to stay an epidemic.

A common rule for measles is to close the infant department of a school for three weeks when the number of actual cases exceeds 10 per cent. of the average attendance. It is more than doubtful whether this is not too high a percentage to wait for before adopting closure. Owing to deficient or belated information the percentage of absentees caused by measles may exceed this number before the medical officer of health is in a position to take action, and he is then in the difficult position of having to decide whether the epidemic will not run its course, school closure or no school closure, and of acting accordingly. No definite rule can be laid down; but generally, if in doubt as to the course to be taken, he will be wise to decide on the side of closure of the infant department. After a three weeks' closure, it is very exceptional for the disease to increase to any considerable extent after reopening.

Of course it may be argued that negligent parents continue to expose their infected children and thus infect the children in neighbouring houses. Even if this be so, the infection is necessarily on a limited scale, unlike that in school (see page 28).

For diphtheria there need, when other measures have failed, be no hesitation in adopting school closure as a preventive measure. It is a most efficacious one. Before adopting it, systematic bacteriological examination of specimens from the children in the implicated classroom, and particularly of specimens from all "contacts," will have been carried out, and infectious children and children possibly infectious excluded.

We have already seen that the medical officer of health can

1. Exclude individual children or families; or
2. Close schools or departments of schools or single classes under Article 88 of the Code; or
3. Exclude children from a particular infected street or neighbourhood.

No power is given to take "swabs" from the throats of infected children, but this can with tact generally be done. If, however, the examination of such "swabs" fails to detect the continuing source of infection in a class, and cases of diphtheria continue to occur at intervals of a few days, there should be no hesitation in excluding all the children in that class from attendance at school for four weeks. Experience has shown us that closure for less than four weeks is not likely to be completely successful. Even after four weeks a recrudescence may occur on the reassembling of the school, but this is exceptional. If cases of diphtheria continue to appear in other classes and in several departments of a school, its entire closure may be necessary. Most commonly, however, it is only necessary to close the infant department or only a section of this.

The exclusion of all children from particular streets is indicated when the children attending school from these streets are alone affected with the disease, and when there is reason to suspect that undetected cases of the same disease have occurred in the same streets. At the same time the medical officer of health should send a letter to each parent in the infected streets giving a warning as to the necessity for watching for sore throat, etc., and as to the danger of allowing children to play in the street.

The **closure of infant schools**, and particularly of the babies' class of infant schools, is more important than that of any other part of the school, and should be resorted to more promptly than in the higher classes. The reason for this is twofold. Such children are more susceptible to infection, and when attacked, the disease is much more fatal. These remarks apply not only to measles and diphtheria, but also to scarlet fever and other infectious diseases. The following illustrative statistics make this plain :—

FATALITY PER 100 ATTACKED.

At Ages	Measles (both sexes).		Scarlet Fever.[3]		Diphtheria.[3]	
	One epidemic.[1]	Another epidemic.[2]	Males.	Females.	Males.	Females.
0 to 1	9·6	4·0	16·5	10·1	35·3	46·0
1 to 2	19·7	5·0	8·8	12·7	37·0	32·7
2 to 3	10·2	3·8	7·2	7·4	23·4	25·6
3 to 4	4·9	3·0	5·0	5·0	20·1	18·1
4 to 5	1·5	3·0	5·7	2·7	14·2	17·3
All ages under 5	8·5	2·3				
5 to 10	1·1	1·0	1·1	1·5	9·6	11·2

An attack of measles is most dangerous between the ages of one and three, and after the age of five is seldom fatal. To complete the story it should be added that not only the fatality (*i.e.*, the number dying for every 100 attacked), but the number attacked by measles to equal numbers living is greater in the earlier ages. Thus in the first of the two epidemics investigated by Dr. Thomson, 72 under one, 119 at ages one to two, 172 at ages two to three, 162 at ages three to four, and 170 at ages four to five, per 1,000 living at each age were attacked, as compared with 62 per 1,000 children aged five to ten.

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[1] T. Thomson, quoted in Newsholme's *Vital Statistics*, third edition, p. 192.

[2] Thomson, *Supplement to Twenty-fourth Annual Report Loc. Gov. Board*, p. 138.

[3] Shirley Murphy, " Ninth Annual Report of Med. Officer of Health of County of London ".

It would be well were children under five entirely forbidden to attend public elementary schools. No educational advantage is secured by their attendance, and many thousands of lives are annually lost by exposing children of two, three and four years of age to the conditions of dense aggregation associated with school life (page 22).

During the school closure it is necessary to have the rooms thoroughly disinfected and cleansed. For this purpose the walls, floors, desks, cupboards, etc., should be thoroughly sprayed or washed out with a disinfectant solution (see page 292). All slate and lead pencils, slates, etc., should be soaked in a similar solution, and books disinfected by steam. Then the ceilings should be whitewashed, and walls and floors again washed.

The subject of medical inspection in relation to the prevention of infectious diseases in schools is discussed on page 172.

The **Prevention of Infectious Diseases in Boarding Schools** presents problems which so far as general principles are concerned are similar to those applying to day schools. In other respects its problems are special and require separate consideration.

The possibilities of spread of disease by laundries, and by milk or other foods, necessitate strict regulations in these respects. The ideal plan is a special laundry and a special dairy.

On the entry of pupils a certificate should be demanded, signed by parent or guardian, stating that "to the best of their knowledge and belief, the pupil has not, for at least three weeks, been exposed to any infectious disease, or entered any house where such disease has existed". It is well to give a list of these diseases on the certificate form, in order that there may be no mistake. No scholar should be admitted among the other pupils without such a certificate. If the certificate is not forthcoming, or if there is reasonable ground for suspicion, the scholar must be placed in quarantine for the period for the disease in question given in column (4) of the table on page 150, and his clothes should be disinfected at the end of this time.

The presence of day scholars in a boarding school is a frequent means of introducing infection. Every encouragement should be given to the parents of day scholars, and it should be made a point of honour with them, not to send their children to school if there is the slightest reason for suspecting the existence of an infectious disease in their homes.

No boarding school can be considered to be satisfactorily performing its work which has no provision for the isolation of doubtful infectious cases, if not of well-marked cases, of the more severe infectious cases, as scarlet fever and diphtheria. In some towns arrangements can be made for the treatment of the latter class of patients in the municipal hospital, and arrangements need to be made only for measles, chicken-pox, etc. But in all boarding schools rooms must be provided to which pupils with suspicious symptoms, as a severe catarrh, a sore throat, or a rash on the skin, may at once be removed for isolation. The temporary isolation is not satisfactory if the matron or nurse attending such doubtful cases also has the care of others suffering from non-infectious diseases, or is in contact at any time with other boarders.

The isolation accommodation should preferably be in a detached building. Occasionally the top floor of a large house may be utilised ; but this is only safe if there is a separate staircase to this floor, if it has separate cooking and other arrangements, and an entirely distinct staff from the rest of the house.

In the isolation building or sanatorium, at least 2,000 cubic feet of space are required for each patient. The sanatorium must have its separate kitchen, laundry, and a disinfecting chamber. The amount of accommodation required in a school sanatorium will vary according to the average age of the pupils, their social status, which will to some extent determine whether they are likely to be protected by a previous attack of each infectious disease, and the administration of the school, particularly the enforcement of health certificates, and the presence or absence of day pupils. The Memorandum of the Medical Officers of Schools Association gives the following example :—

> "In a large boarding school containing 300 or more boys with an average age of between twelve and fourteen—the average age of leaving school being about eighteen—it may be stated that, *in order to provide proper accommodation for treating full outbreaks of epidemic illness, and allowing for two or more infectious diseases being epidemic in the school at the same time*, the number of beds available in the sanatorium should equal 20 per cent. of the total number of boarders. This allowance does not include the provision needed for servants. Very few boarding schools have isolation accommodation on anything like the above scale ; but even this accommodation might all be exhausted in an outbreak of measles. If, however, 20 per cent. of the pupils were attacked, the futility of further attempts at isolation would require consideration."

When a case of infectious disease occurs in a school the parents of the other pupils should at once be advised of the fact, the precautions that have been taken being stated. By this means confidence tends to be established, and there is no scope for the alarmist rumours that may otherwise arise. Occasionally parents will under these circumstances temporarily withdraw their children. In a boarding school where the master, guided by his medical adviser, is an autocrat, it ought never to be necessary to recommend breaking up the school and dispersing the scholars, unless an outbreak of disease is caused by some local sanitary defect, which can only be remedied when the children are away. A possible exception to this rule might occur for diphtheria ; but even in this disease, as suspected pupils may so to speak be filtered back from quarantine after three successive negative bacteriological examinations of "swabs," dispersal of scholars ought seldom if ever to be required.

CHAPTER XV.

THE MEDICAL INSPECTION OF SCHOOLS.

FREE access to medical advice and assistance is as necessary to the teacher to enable him to carry on his work with complete success as are efficient ventilation and sanitary school buildings ; not only in preventing the spread of communicable diseases, but also on many points relating to the physical and mental condition of the pupils.

Medical Inspection in Relation to Infectious Diseases.—The necessity for school closure may occasionally be avoided and the incidence of infectious diseases in school children reduced to a minimum by systematic medical examination of suspected children in school. The medical officer of health possesses no legal power to make such an examination. Indeed, an examination of a child's throat or even of its skin if it involves handling the child is, unless the parent's or guardian's consent be obtained, a technical assault. With the co-operation of the teacher the necessary access to scholars can usually be obtained without difficulty. Such an examination is generally confined to the detection of desquamation, discharge from the ear or nose, or other signs suspicious of scarlet fever, or to the detection of sore throat, enlarged glands, or excessive pallor, in diphtheria ; or "swabs" may be taken for bacteriological examination (page 145) from the throats of children who have been in contact with cases of diphtheria, or are themselves under suspicion.

Various difficulties arise in securing medical inspection of schools, even on the limited scale indicated above.

1. Clearly a medical man should be available for each school soon after the assembly of the morning school. Even with a complete system of telephonic communication it would be impracticable for the medical officer of health of a large district to be available at all the required points. Hence the necessity for special school medical officers (*vide infra*).

2. It is obviously impracticable for a medical inspector, even if he visits each school daily, to examine each scholar individually and daily. This would interfere too greatly with school work, and the proportion of infectious cases discovered would ordinarily be so small that with such a system there would be great danger that the work would in time be perfunctorily performed. The medical inspector must in actual practice confine himself chiefly to the examination of children selected by the teacher, the selection being made by the latter on the strength of either (*a*) the occurrence of suspicious symptoms, or (*b*) suspicion arising from failure to attend school during a few preceding days. Hence the system of medical inspection will only work efficiently when the teacher co-operates intelligently and with a full appreciation of the importance of submitting the proper cases under the headings (*a*) and (*b*) to the judgment of the medical inspector.

In some towns special **medical officers to School Boards** are appointed. These have seldom been appointed specially for carrying out the work mentioned in the last paragraph, but occasionally they have done it, especially during outbreaks of infectious disease, with beneficial effect. In the United States and in certain other countries medical inspectors have been appointed who have done similar work (p. 175).

Practical experience has convinced us that too much must not be expected of medical inspection at the school. It will effect much if intelligently utilised, especially in the direction of examination of temporary absentees on their return to school. But even then, many cases, particularly of scarlet fever and diphtheria, may be missed. Thus a child returns after four days' absence, having had a slight attack of scarlet fever. The rash has disappeared, there is as yet no desquamation, and the child himself cannot give an exact account of his symptoms during the last four days. Or after a week's interval, a child having had a slight attack of diphtheria returns to school. Unless a bacteriological examination of the throat is made, the medical inspector may easily be misled. The only safe rule, therefore, is when in doubt to continue exclusion until further medical inspection can be made at the patient's home, and the possibility of infection can be more definitely excluded.

The difficulties briefly indicated above can only be partially met under the present conditions of modern life, especially in towns. Parents earning under 30s. a week cannot be expected to call in a doctor for what they regard as trifling complaints. Even when a doctor is consulted, the parents may be obliged to call in one who gives advice and medicine for a fee of sixpence or a shilling, and who, to compensate for the smallness of the fee, must see such a number of patients that he cannot give sufficient attention to each. Still oftener, parents fall into the hands of druggists, who diagnose scarlet fever as nettle rash, diphtheria as ulcerated sore throat, and so on. This state of matters, as pointed out by one of us,[1] "can only be remedied by having medical aid, to a certain extent, available for the labouring classes gratuitously in every district, without any implication of pauperism being involved in securing its advantages. . . ." This will involve a State Department of medical aid for free diagnosis, if not for free treatment, in the first instance, at least. The sanitary authorities, and the School Boards and other school authorities, would greatly benefit by the adoption of such a State system of early medical aid, for no " parents could then plead that considerations of expense had prevented them from calling in medical aid, and one of the greatest advances in Public Health hitherto made would by this means be secured ".

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[1] A. Newsholme, *Practitioner*, 1900, p. 192.

Medical Inspection of Schools in the United States.—In several American cities this has been made systematic, instead of being confined, as in England, to occasions when special inquiries as to infectious diseases or defects of eyesight are undertaken. Boston is divided into fifty districts, a medical inspector being appointed for each at a salary of 200 dollars per annum. Each inspector has four or five schools, and about 2,000 children under his charge. He is required to visit at their houses, at least twice, all cases of diphtheria and scarlet fever reported in his district. He also visits each school soon after the opening of the morning session, the teachers submitting for examination any children who appear to be ill, or in any way to need the advice of the inspector. The teacher's intelligent co-operation is therefore indispensable. In both Boston and in other cities, medical inspectors exercise some supervision over the vaccination of scholars. For their method of managing pediculosis, see p. 179. New York has 205 medical inspectors, each with a salary of 360 dollars, with a chief at a salary of 2,500 dollars. These inspectors examined 139,965 children in 1898, and excluded 7,606 for various infectious diseases, or for contagious diseases of the eye, skin and scalp.

General Medical Inspection of Schools.—In the preceding remarks we have indicated the extent of the utility of medical inspection for the detection of infectious diseases in school. Such detection does not constitute the sole reason rendering the appointment of medical inspectors desirable. In the following respects their appointment would be of the highest value :—

Firstly, even more troublesome in elementary schools than acute infectious diseases are the grosser contagious diseases of the eyes, skin and scalp, especially ringworm and pediculosis. The London School Board has appointed nurses to instruct parents as to the treatment of ringworm and pediculosis (lousy heads), and to arrange for the exclusion of children thus affected from school. Many cases of ringworm will, however, be missed unless diagnosed by a medical man (see page 180).

Secondly, many children are prevented from deriving the proper benefit from their tuition by "artificial stupidity," due to defects of eyesight or hearing. These children should be submitted to medical advice, and parents be instructed how to proceed (pages 102 and 46).

Thirdly, children with chorea (St. Vitus's Dance) or with other nervous affections, which are readily recognised by a doctor, should be withdrawn from school attendance. So also should children showing evidence of nervous prostration.

Fourthly, the general sanitation of a school, especially its ventilation and warming, will be more efficient, when under the supervision of a skilled inspector.

Fifthly, school books, desks and seats, and other apparatus, in relation to the posture of children, can also be supervised by the medical inspector.

Physical Examination of Children.—Reference has been made above to the importance of medical examinations for the detection of defects of eyesight and hearing among school children. The same remark applies to the detection of lateral curvature of the spine, which not infrequently occurs among rapidly growing girls about the age of puberty. The teacher ought to be able to refer any scholar about whose physical well-being he or she was dissatisfied to a medical inspector for examination and advice.

Although it is impracticable in large elementary schools periodically to measure and weigh each scholar, the value of such tests (p. 28) has been already indicated. A beginning might be made by instituting a medical examination of every scholar on first entering school, and again when he leaves the infant school for the upper school. By this means valuable information as to defects of eyesight, adenoids, or other conditions impeding education, would be secured, and the necessary advice could be given to parents.

Dental Condition of Children.—Much ill-health and consequent irregularity in school attendance is caused by bad teeth. In elementary day schools it is impracticable to undertake the charge of children's teeth, though the foundations of permanent ill-health are being laid in many instances by neglect of the teeth during school life. In resident industrial schools efforts are now being made to remedy this serious cause of disease by the appointment of dentists, who "fill" carious teeth, correct irregularities of the teeth, and generally take steps to improve the hygiene of the mouth. It is not sufficiently recognised that it is quite as important that carious temporary or "milk" teeth should be filled, as that similar treatment should be applied to carious permanent teeth. For a valuable discussion of the whole subject reference may be made to Mr. Denison Pedley's *Hygiene of the Mouth.* He gives the following statistics of the dental condition of 3,800 boys and girls, aged three to sixteen years, in industrial schools. Among 1,786 children under ten years of age there were 3,187 temporary teeth requiring to be filled, *i.e.*, teeth which could be saved. Among the same children 2,491 teeth required extraction. Between the ages of nine and fourteen inclusive 2,753 teeth in 2,543 children (more than one to each child) required filling.

CHAPTER XVI.

COMMUNICABLE DISEASES IN SCHOOL LIFE (*continued*).

In elementary schools much inconvenience and distress is caused and the schools are depreciated in repute among respectable parents by the great frequency with which chronic contagious complaints, caused by lice in the head or by ringworm, occur.

These diseases can only be prevented from spreading, where large numbers of young children daily congregate, by the most rigid attention to cleanliness. In the routine of school life the two most important points are that (*a*) each scholar should have a numbered peg for his cap or hat, and interchange of pegs or of head coverings should be strictly interdicted ; and (*b*) each scholar should have a separate desk or otherwise be prevented from leaning against other scholars. More intimate contact of heads cannot be entirely prevented during play-time, and it is very desirable therefore (*c*) to discourage the wearing of long hair, especially in children under ten years of age, whether boys or girls. A close crop is the best means of securing cleanliness and of preventing ringworm, for instance, fixing itself thoroughly in the scalp before it is detected.

The head louse (*pediculus capitis*) is about $\frac{1}{12}$ inch in length. It lives amongst the hair of the scalp. It lays an enormous number of eggs or *nits*, each of which, about $\frac{1}{20}$ inch in length, is fixed to the shaft of a hair by a resinous substance. These eggs take from five to eight days to hatch, and the louse thus hatched begins to lay eggs in about three weeks. The appearance of the nits is well known. They can at once be recognised and distinguished from scurf by being incapable of being brushed or rubbed off the affected hairs. As each nit represents a prospective louse, no child can be said to be free from lice, or **pediculosis**, until all nits have been removed.

The management and control of pediculosis requires stringent measures. Not only are other children frequently infected, but girl pupil teachers may also suffer seriously. In London good work has been done in this connection by the nurses of the London School Nurses' Society. Each nurse visits four schools in one day and sees about one hundred children, who are sent to her by the teacher. The nurse attends to such small ills of the scholars as sore heels, inflamed eyes, or dirty heads. The report of the Society states: "It is found that cases of bad eyes and dirty heads are practically stamped out of a school by six months regular visiting; consequently, each nurse is able to enlarge the scope of her work as time goes on". When lice in the head are detected the next step is to send a suitable intimation to the parent. The plan adopted in Boston, U.S.A.,[1] may be commended for imitation. The following letter is sent to the parent:—

..............................School,
Boston,..............................190 .

.... has been reported by the Medical Inspector of Schools as showing parasites in the hair, and I am therefore obliged to request that the child be kept out of school for a few days until the disease is cured.

..............................*Master.*

The following method of treatment for killing parasites and nits is recommended by the Board of Health:—

Wet the hair thoroughly with crude petroleum. . . . Keep it wet for three hours. Then wash the whole head with warm water and soap. Repeat this process on three successive days. The nits may then be removed by combing the hair very carefully with a fine-toothed comb wet with vinegar. Repeat the combing for several days until no more nits can be found. To make the treatment easier and more thorough, the hair may be cut short if there is no objection.

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[1] Dr. Chapin, *Municipal Sanitation in the United States*, 1901, p. 786.

All the children in a family are likely to be affected, and should also be treated as above.

Brushes and combs should be cleansed by putting them in boiling water for a few minutes.

The child is then not re-admitted to school until he brings the following slip signed by the parent :—

I hereby declare that on three different days during the past week I have applied crude petroleum to my child's hair, as directed on the card received.

In **Scabies** or **Itch** the insect causing it burrows into the skin and does not merely live on its surface like the louse. Itch shows itself in the form of an irritable rash, most frequently seen between the roots of the fingers and in the bends of joints, especially at the wrist. It is due to the rapid multiplication of a minute insect not unlike a cheese-mite, the female of which forms oblique burrows in the epidermis, laying eggs which hatch in about fourteen days. The rash simulates eczema, and is liable to spread all over the body if its true nature is not detected. It is very contagious, and no child who has had it should be allowed to return to school without a medical certificate, and until his clothes have been baked or washed in boiling water.

Of diseases caused by vegetable parasites **Ringworm** is the most serious. It is due to the growth on the skin of a minute fungus, each cell of which is only visible when magnified. Minute spores become detached from the growth, and thus contagion is carried elsewhere to the same person or to others by means of change of caps or bonnets, or by towels or brushes, or actual contact. Hairdressers occasionally communicate ringworm, and so do hatters by trying on numerous caps. It is as morally wrong to send a child with ringworm to a hairdresser or hatter as if he were suffering from scarlet fever.

Ringworm is extremely common among children, in some districts almost as common as pediculosis. On the bare skin it can be recognised by the ring-like patches with raised margins which are formed, the ring gradually widening out if not interfered with. On the scalp similar patches are formed, but the fungus extends down to the roots of the hairs, and obstinately remains there, even when the superficial parts have been apparently cured. It frequently happens that such children are allowed to return to school, the disease breaking out again, and conveying the contagion to other children. It is quite a mistake to suppose that ringworm is necessarily cured when the hair begins to grow on the diseased places. A case can only be regarded as cured when a medical man, after having carefully examined the whole scalp in a good light and scrutinised every suspicious spot with a lens, has found no broken-off stumpy hairs (often not protruding more than $\frac{1}{16}$ to $\frac{1}{8}$ inch).

It is unfortunately a fact that many children recovering from ringworm are certified by indiscreet medical men to be free from infection, when a more careful examination discovers numerous hairs in which the fungus is still alive. One commonly hears the remark that " the ringworm is better, but has left a scurfy condition of the head behind ". The teacher may take it as a practical rule in such cases, which will very seldom be found to err, that the *scurfy condition* indicates a phase of ringworm which *is still contagious.* The power to convey contagion may last for a year or two in untreated cases. The first point in *treatment* is to cut the hair close to the scalp, so that the exact extent of the mischief may be seen. Then the applications ordered by a doctor must be persistently applied, and the scalp must be kept frequently cleansed as directed by him.

Catarrhal Ophthalmia is marked by redness of the eyes and free muco-purulent discharge. It lasts about fourteen days, and is chiefly important because it is contagious.

Chronic Granular Ophthalmia is also contagious, and all cases should be isolated, and the use of the same towels, or water, forbidden. Badly ventilated dormitories, insufficient food, and general unhygienic conditions with the promiscuous use of towels, are chiefly instrumental in producing and spreading it (see also page 100). It is not common in elementary day schools, and does not tend to spread in them.

Scald Head (Contagious Impetigo) is common in underfed children. It may spread to other children, under similar conditions; and such children should therefore be excluded from school. So should children suffering from eczema or other conditions of the skin accompanied by *scabbing*, which are all liable to be passed on to other children by direct contact.

The following remarks are extracted from a "Circular to Managers and Teachers of Urban Elementary Schools," issued by the Board of Education in October, 1901:—

> The sight of children is liable to be injuriously affected by two distinct classes of conditions, namely:—
>
> (*a*) From what are technically called errors of refraction (these are described pages 102 to 108).
>
> (*b*) From various forms of disease, such as contagious or non-contagious ophthalmia, eczema affecting the lids, inflammation of the follicles of the eyelashes, pimples or pustules upon the eye surfaces, or inflammation or ulceration of the cornea. Many of these forms of disease are inconspicuous in their origin and might easily escape notice unless special attention were paid to the possibility of their occurrence. Some of them are highly contagious, and might become of serious import to the school as a whole, as well as to the original sufferers.

In relation to class (*b*), which manifestly includes affections of very different kinds, some of them comparatively rare, others sadly too common, it is difficult to lay down any other general rule than that it should be the duty of teachers to observe any appearance of unnatural redness or soreness of the eyes, or any tendency on the part of a child to be often rubbing them when at work, and to take such precautions as the circumstance of each case may require. Two especially common forms of disease are the contagious ophthalmia chiefly affecting the insides of the eyelids, and the contagious ophthalmia affecting the lid margins, and tending to destroy the eyelashes at their roots. Both of these are liable to be aggravated by insanitary home conditions, and both are contagious from child to child, either directly, by finger contact, or through the medium of slates, towels, sponges, needlework, and so forth. In many cases, treatment, to be effective, must be continued for a long time, and personally undertaken by a trained nurse or a surgeon. The parents often have not time or perseverance to take the suffering child regularly to the local eye hospital; and the records of workhouse infirmaries show that children suffering from either of these forms of disease constantly become " ins and outs," ceasing to attend when the acute symptoms disappear, and returning when the disease is again virulent, having attended school in the interval at great risk of spreading the disease. The effects of both the above-mentioned forms of ophthalmia upon the sight are frequently serious, and, even if the subject should escape with useful though impaired vision, the appearance given to the face, by the deformity of the eyelids and by the loss of eyelashes, is often such as to relegate him to the lowest kinds of employment. Managers and teachers, especially in poor districts, are therefore recommended to be watchful with regard to this matter, to exclude any child that is affected, and to take care that he shall not be re-admitted without a medical certificate of fitness. The Board of Education have learnt with pleasure that in a few cases special ophthalmic schools have been established in which children can be kept and educated until a cure is effected. The inflammation of the lid margins is usually rendered manifest by the formation of crusts or scabs at the roots of the eyelashes, but the contagious inflammation affecting the lid linings may not only for a long time remain inconspicuous, but is often difficult to distinguish from non-contagious forms affecting the same locality. If any doubt should arise medical advice should always be sought for its determination.

School Visiting Nurses.—In attempting to solve the problems

> presented by the evils above referred to school authorities are confronted by a twofold difficulty. In the first place a large proportion of the cases require special skill for their detection; and hence, unless expert knowledge is brought to bear, it is only too probable that many will be overlooked, to the detriment of children who may be subjected to unjust censure and punishment, as well as to overtaxing and further deterioration of the sight. In the second place, even after the discovery of an abnormality, it is not always easy to bring home to the parent the need for treatment, especially if the latter involve an expenditure of trouble, time, or patience. The Board of Education have learnt with satisfaction that in a few large cities the employment of school visiting nurses is being commenced. They are provided, it is believed as a rule, by voluntary associations to schools applying for them. The nurse attends during school hours and sees all children who are referred to her by the teachers, the cases being principally eye or skin diseases, discharging ears, sore and dirty heads, gathered fingers and heels, chilblains, etc. It has been found necessary to give these "school nurses" some special instruction with regard to eye troubles, the detection and treatment of which may require exceptional knowledge and skill. The nurse is able to decide what children require medical advice or treatment, and to lessen the risk of contagion by recognising infectious complaints in an early stage. Managers and teachers, as well as H.M. Inspectors, have testified to the value of these nurses in improving the health of the scholars and in increasing the regularity of attendance. Cases must occasionally occur where, through misfortune or otherwise, a parent is unable to take a child to a hospital, or otherwise to seek medical advice. In such cases managers are earnestly advised to co-operate with teachers in devising means by which children incapable of profiting by instruction in school may be enabled to receive appropriate treatment.

The circular then goes on to draw attention to the following points as indicating the necessity for skilled help:—

> (*e*) The appearance of white or milky spots over any part of the centre of the eye.
>
> (*f*) Red or watery eyelids, rims of the eyelids red or prominent, with or without discharge.
>
> (*g*) Eyelashes matted or partially absent, with or without scabs at their bases.

(*h*) Temporary pain, swelling and inflammation of the lid. (Stye.) In calling attention to these defects the teacher may co-operate efficiently with the school nurse and may thereby facilitate the labour of the latter to a very great extent.

The above circular contains useful information, but the allusion to school visiting nurses is somewhat unguarded. These have done excellent work in treating chilblains, etc., in encouraging cleanliness, and in securing the temporary removal from school of children with ringworm or lousiness. To assume, however, that they are competent to treat discharging ears, or to decide in all cases whether medical aid is required is going beyond what is wise. Discharging ears require skilled and continued treatment. They are a frequent eventual result of adenoids (see page 47), and every teacher ought to be instructed in detecting the mouth-breathing, which is a sign of these, in order that he may advise proper medical treatment before serious mischief is done. Medical inspectors are required as well as nurses in order to meet the evils set out in the circular from which extracts are given above.

PART II.

SCHOOLS.

CHAPTER XVII.

SITE AND SURROUNDINGS.

UNFORTUNATELY circumstances often prevent a choice being exercised in the selection of a site for a school. In the instances, however, in which a choice of situations can be made, the following considerations require to be taken into account :—

1. **The Soil or Humus.**—This is the thin top layer of the ground varying from nine to eighteen inches in depth, in which vegetation grows. It differs from the underlying layers, in that it contains much organic matter derived from the death and decay of living organisms, both vegetable and animal.

Under ordinary conditions the soil has the power through the agency of certain bacteria, which it contains in enormous numbers, of disposing of dead organic matter without giving rise to offensive odours. If, however, as sometimes occurs, there is too much organic matter on a given area, or if the soil is water-logged, this beneficent process is inhibited. Then the organic matter putrefies and offensive odours are exhaled. The neighbourhood of rank vegetation should on this account be avoided.

In towns, hollows are often filled up with rubbish constituting what is known as "made soil". The rubbish almost invariably contains large quantities of organic refuse which undergoes putrefaction and becomes offensive. As it takes years for such a soil to become innocuous these sites must be avoided.

2. **The Subsoil.**—The earth's crust consists of rocks of different kinds arranged in layers or strata. The

deepest layers consist of rocks which are hard and impermeable to water, and since they originated in the cooling of the earth from the molten state they are termed Igneous. Originally they formed the external crust of the earth, which had not a smooth but a corrugated surface. Through the agency of rain, wind, sun and frost, these rocks were gradually worn away, and the fine particles resulting from this process were washed down from the hills into the valleys, where they settled usually under water, and produced the rocks, called from their origin Aqueous, to distinguish them from the older Igneous formations mentioned above. During the course of millions of years these layers acquired immense thickness. As the earth's crust still continued to cool, great upheavals slowly took place, what were hills becoming valleys and what were valleys hills. Now in their turn these Aqueous rocks were worn away and new layers formed in the valleys. The rocks thus formed were naturally different from those formed by the detrition of the Igneous rocks ; moreover, some of the constituents were more soluble in water than others. In this way the arrangement of the earth's crust in layers and the varying character of the soil at different points is accounted for. For our purposes we may make a simple classification of these formations into two divisions, (1) those formed of coarse particles, such as sand and sandstone, which allow water to pass through, and (2) those composed of very fine particles, such as clay and slate, which are impermeable.

The subsoil is the particular layer which lies immediately below the soil, and, as often happens when it is composed of chalk, may be hundreds of feet in thickness.

The strata belonging to the first class are not all permeable to the same degree ; sandstone, for instance, owing to its finer texture, will allow water to percolate through it much less readily than will gravel.

Other things being equal, the coarser the texture of the subsoil the drier will be the soil, and the less danger will there be of damp getting into houses built upon it. This is the reason why dwellings built upon gravel are generally considered so desirable to live in.

Again, the impermeable strata are of two kinds: (1) those which absorb little moisture, such as some of the hard rocks; (2) those which absorb a considerable amount, such as clay.

If proper arrangements are made by drainage to prevent water from lying on hard rock a dry site is obtained, but clay will always be more or less damp on account of the water it absorbs. It may happen, however, owing to the conformation of the ground, that a clay site on sloping ground is less damp than a gravel site in a valley.

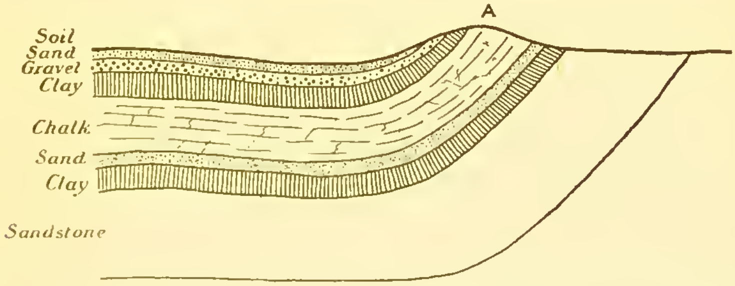

FIG. 11.—Section through earth's crust showing strata and outcrop at A.

Subsoil or Ground Water.—The rainfall upon a particular area is disposed of in several ways. Some of the water runs directly away by streams or sewers, some evaporates from the surface, some is taken up by the humus, while a considerable portion may filter through to the subsoil. At first the subsoil takes up the water like a sponge, but as more and more water reaches it from above, the point of saturation is finally attained. It is then unable to absorb a further supply. Any more water filtering through to the subsoil now collects in its lowest layers in a continuous sheet, since it is prevented from escaping by the impermeable rock or clay below. This sheet is called the Ground or Subsoil Water, and when surface wells, which penetrate only so far as the subsoil, are sunk, it is from this continuous sheet of water that they obtain their supply.

The Ground Water is not stationary but constantly flows slowly towards the river, lake or sea which forms its natural outfall.

It will be readily understood from the above description that the proximity of the ground water to the surface will depend upon the depth of the subsoil; if the first impervious layer is only a few feet below the surface there will be danger of the ground water reaching nearly to the surface, and unless special precautions are taken a school built above it will be damp. If on the other hand the impervious layer is several hundred feet below the surface, all the water will drain through and the upper layers of the subsoil will be relatively dry. There is still another danger when sudden heavy falls of rain occur. Then the ground water rises sometimes many feet in a short space of time, owing to the incapacity of the outlet of the subsoil, often many miles distant, to discharge the excess of water as promptly as it soaks into the subsoil. Thus

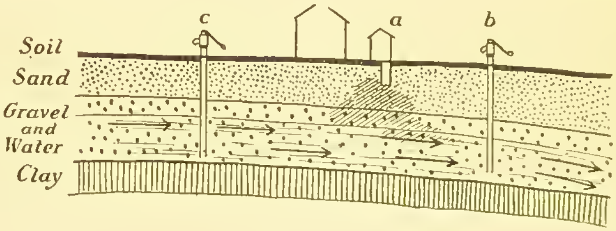

FIG. 12.—Showing flow of ground water and possible pollution from a privy *a* contaminating well *b* but usually not well *c*.

although in dry weather the site may be dry, in wet weather it may be damp, especially when the subsoil is shallow.

If possible no house should be built on a site with the ground water nearer the surface than ten or twelve feet. But such a site is better than one where the level is subject to great variations, as in the latter case dangers arise both from ground water and ground air. **Ground air** is the air filling the interstices of the subsoil above the level of the ground water. It differs considerably from the atmospheric air; its amount of oxygen is much less, of carbon dioxide (CO_2) and moisture much greater. Furthermore, it contains the gases produced by the decomposition of all organic matter percolating into it, which are often noxious. When rain falls on to the soil the surface water may prevent the ground air from coming out. Being thus compressed it forces its way out at points which are protected from rainfall. If a house is built in a field, and no precautions have been taken to render the floor impervious, a heavy shower on the field will force the ground air into the house. The ground air may travel for considerable distances before it emerges into the atmosphere. Coal gas, for instance, has been detected in a house many yards away from a leaking gas main.

Subsoil Drainage.—Unless the subsoil is of a great depth and very porous the water is carried away but slowly; to prevent the possibility of dampness from this cause, and to obviate the dangers arising from the fluctuations of the ground water, the site must be drained. This may be done by digging trenches sloping towards the outfall and laying agricultural pipes in them. These pipes are porous cylinders of burnt clay and are placed with a slight interval between them; thus providing an easy channel for the escape of water. If it be necessary to connect these pipes with the sewer, this should not be done directly but by means of a disconnecting chamber.

Subsoil drainage becomes a very difficult problem when the site lies in a valley, on the banks of a large lake, or in flat, low-lying country like the Fen district; because the ground water in these places lies close beneath the soil, and there is not sufficient fall to enable efficient artificial drainage to be carried out.

A damp soil is necessarily cold, and cold and damp foster a condition of the system which favours the occurrence of bronchitis, consumption and possibly other diseases.

The popular notion that clay is damp and gravel dry is not, however, universally true. Clay on a hill which is capable of efficient drainage is less damp than gravel in a valley which is incapable of drainage.

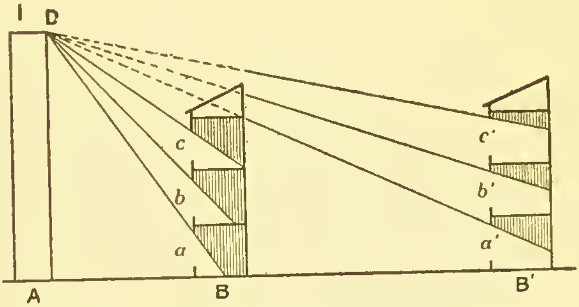

Fig. 13.—Showing effect of width of street on measure of illumination of rooms on different floors. A B, narrow street; A B′, wide street.

3. Surroundings.—The chief points to be considered in the surroundings of a school relate to light, ventilation, noise and noxious odours.

In order that there shall be abundant light and ventilation, trees and buildings should not be too near. Trees on the east and north are permissible in order to shelter the school from cold winds; but if too close they prevent through ventilation, and shut off the north light which is always a steady light and excellent for school work. In the above diagram the effect upon the light of near buildings is very evident. With the building A at a fixed point, and the light coming from over D, the difference in the lighting of the rooms *a*, *b* and *c* is well marked; *a* and *b* are both badly lighted, even *c* is only fairly lighted because no light gets upon the back wall; *a'*, *b'* and *c'* are all well lighted. It will be noticed that unless the angle A B D is less than 45° no light will reach the back wall, and the smaller this angle is the better will the room be lighted.

As a minimum it may be stated that two sides of the school should be at least 60 feet from any neighbouring houses or trees, and some portion of this space should be used as the playground.

The proximity of sources of noise, such as main roads, railways, manufactories where machinery is at work, etc., should be avoided. Distraction is caused by occasional noises, and nervous strain by a constant noise. Furthermore, children's attention is easily distracted.

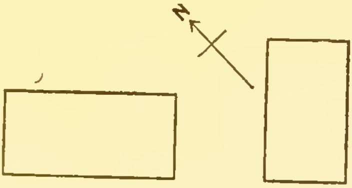

FIG. 14.—Showing best orientation in relation to lighting of school.

The objection to smells arising from stable yards, india-rubber works, tarpaulin works, tan yards, soap works, chemical works, gas works, etc., is obvious.

The position of the building as regards the points of the compass is of some importance, for it is highly desirable that the sun should have access to every room at some part of the day. This can best be accomplished by having the corners of the building towards the four cardinal points. (Fig. 14.)

CHAPTER XVIII.

STRUCTURE OF THE SCHOOL BUILDINGS.

THE preamble of Schedule VII. of the Day School Code, 1899,[1] contains the following passage which should always be kept in mind :—

> "School planning is the science of thoroughly adapting every part of a building, even the minutest detail, to the work of school teaching. Convenience of plan, suitable lighting, proper subdivision into classes, and thorough ventilation, with warmth, but without draughts, are its leading essentials. *Attention to small points is of extreme importance. Sanitary laws are here as vital as in an hospital.*" (Our italics.)

Although the planning and building of a school are generally relegated to the architect and builder respectively, the teacher should understand the principles which underlie the arts of designing and constructing.

The school buildings include the actual school, the residence of the teacher, the playground and the offices. As little need be said under this head, it will be convenient to consider first

The Teacher's Residence.—Section 19 of Schedule VII. of the Day School Code (1899) (p. 305) gives the minimum requirements for the residence of an elementary schoolmaster or mistress. In addition to these requirements the building must of course conform to the building bye-laws locally in force as to foundations, thickness of walls, roofing, sanitary arrangements, etc. The rules concerning foundations, walls, roofs and sanitary construction are similar to those for the school.

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[1] The whole of Schedule VII. is printed in the Appendix.

The sitting-room, kitchen and scullery should be on the ground floor. The W.C. is often conveniently placed in the half landing, and must be ventilated by a window in an external wall. The ventilation of the house must be carefully supervised. The staircase should be well lighted and form a chief means of ventilating the whole house. The windows, doors and fireplace of every room—every bedroom being provided with a fireplace—must be arranged so as to secure ample lighting and ventilation.

The School Buildings.—*The general plan* of a school may be best studied in the case of a small school, the same principles being applicable for a larger school.

In drawing out the plan of a school the three chief points to be considered are : (1) the number of pupils and whether the sexes are mixed or not ; (2) the number of different rooms required for the different subjects taught and for scholars of different ages ; and (3) proper and efficient lighting. When a school is built many minor alterations may make the heating, ventilation, etc., more efficient, but if the above three points are not provided for at the inception of the building, practically nothing short of rebuilding will remedy the defects.

1. The Accommodation.—The English Day School Code lays down a minimum of 10 square feet of floor-space per child (page 299). In regard to infant schools see p. 305. This minimum is too small, and is happily considerably exceeded in most of the secondary schools. Twenty square feet is a much more satisfactory space. In a room 40′ × 30′ the English Code would allow 120 children, but in a high school, probably not more than sixty would be allowed.

Not only the floor-space, but the cubic-space per child must be taken into consideration. The English Code says that schoolrooms should be at least 12 feet high; if the superficial area is more than 360 square feet, 13 feet high; and if more than 600, 14 feet high (p. 297). In the first case if the room is 20′ × 15′ and 12 ft. high the cubic capacity is 3,600; reckoned from the floor-space, thirty children can be accommodated; there will therefore be 120 cubic feet per child. The minimum cubic space for sleeping per person in a common lodging-house is 300 cubic feet. The high school standard is therefore not excessive. The education authorities are now rightly trying to limit departments of schools to an accommodation not exceeding that required for 300 scholars.

2. The number of rooms will be regulated to some extent by the number of scholars and teachers and the different subjects taught. Except for rooms where all the scholars congregate for special occasions, the schoolrooms should not be made to accommodate more than forty, the largest rooms should therefore not exceed 30 × 24 × 13. Rooms for special purposes, as for small classes, music, etc., may be much smaller.

3. Lighting.—The lighting must be efficient and proper. What constitutes efficiency will be described later. Whenever possible the maximum lighting should be from the left of the scholar, and a smaller amount from behind. By this arrangement the scholars when reading have no shadow upon their books, and when writing have only the shadow of the hand and pen on the right of the pen. If it be impossible to arrange for a left light the next best is from the right and from behind. If the main light is from the right, although the hand and pen throw a shadow in writing the rest of the paper will be well illuminated. The light must never come from behind alone, as the scholar's book is then in the shade: and it must never be admitted from in front of the scholar owing to the glare.

Other points to be considered in planning a large school are the corridors, staircases, cloakrooms, lavatories and water-closets.

The **Corridors** should be roomy, well lighted and capable of thorough ventilation. If necessary they may be lighted partially from the schoolrooms, but the latter must never receive their main light from the corridors, and the corridors must not be placed so as to impede the lighting of any room. The **Staircase** should, in a large school, always be duplicated so that in case of fire there will be two possible modes of egress. Each stair must be oblong in shape and interrupted by comparatively large landings at intervals of about every fifteen steps so as to avoid falls from a great height: spiral staircases must never be allowed. The staircase must be easy of access and fireproof. Doors of classrooms must never open directly on to the head of the stairs ; a landing should always intervene to prevent accidents being caused by children rushing out of the room down the steps. The doors at the foot of the steps should be wider than the stairs to avoid blockage in case of panic.

Cloakrooms should be provided for the scholars' hats, cloaks and umbrellas. These should never be allowed in the schoolrooms. In a large school several cloakrooms should be provided, contiguous to the classrooms. More than one cloakroom should be provided if it be necessary to accommodate more than 100 or 120 scholars. Each cloakroom should have two doors, one for ingress and one for egress. The gangways must be at least four feet wide and the hat rails in two rows, the pegs being at least one foot apart to prevent possible infection or the wetting of clothes on neighbouring pegs. The pegs should be numbered, and each scholar should have his own number to prevent confusion. Special umbrella stands should be provided, and channels should be provided to enable the drippings to escape freely and to discharge outside the building. The cloakroom should be well-lighted, and well-ventilated in order to carry off any moisture from the clothes; the ventilation must be completely independent of the schoolroom. Hot-water pipes should be supplied and arranged so that all the clothes are subjected to an upward current of hot air.

Lavatory Basins should be provided near the cloak-rooms. Lavatories must be provided separately for the teachers and for boys and girls (p. 299).

Water-closets must be provided separately for each sex and for the teachers, and urinals for the boys. If the closets are in the building they must have at least one window opening into the external air, unless they are included in an efficient system of artificial ventilation. In primary schools the closets and urinals must be outside the school building. The minimum numbers will be found in the Day School Code (see Appendix, p. 302).

If there is to be a **Gymnasium** or **Bath**, special provision for these will require to be made on the ground floor or in the basement.

It is only necessary to say a word concerning the **Architecture** of the building. Nothing must be allowed which will interfere with lighting or ventilation. Without being too ornate the building should be made as attractive as possible.

Foundations.—The building must be put upon a solid foundation. If the subsoil is hard rock, clay, etc., little artificial foundation is required. If sand or smooth gravel is met with, it may be necessary—for a large building—to excavate trenches for the main walls until clay, rough shingle or hard rock is found. The trench is then filled in with concrete to within two or three feet of the surface if there is to be no basement, and the walls are laid upon the concrete.

No damp must be allowed to get into the building from the soil. In order to secure this, what are known as damp-proof courses are used. If there is no basement, the dryness of the wall and of the floor ensured by inserting in the wall just above the ground-level a course of glazed perforated bricks, or asphalt (Fig. 15). If there is a basement, the best means is to line the bricks with asphalt in the manner indicated by the thick black line in Fig. 16. The asphalt is laid on when hot and in a half liquid condition: when cold and set it is quite impervious to moisture.

The space included within the foundations must be levelled and covered with a layer of cement six inches thick in order to prevent the ground air from being aspirated or propelled into the school.

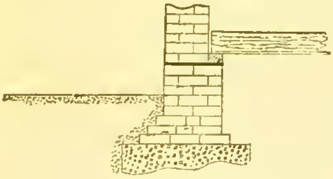

Fig. 15.—Damp-proof course above level of ground.

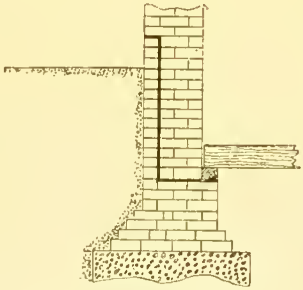

Fig. 16.—Damp-proof course below level of ground.

The Walls may be of brick or stone. Care must be taken that the external aspect of the wall is well pointed with cement so that rain shall not find any lodgment whence it may soak into the brick. The internal aspect should be cemented preferably with smooth cement like Keen's, presenting a perfectly smooth impervious surface capable of being painted. Ordinary plaster has a rough surface and cannot be painted until it has been on the wall for many months; moreover, it is not impervious to moisture or to air.

The Roof must be completely boarded underneath the slates, and it must be constructed in every detail in accordance with the rules governing the best building work. Leaky roofs are a constant source of damp walls, especially in the upper stories.

The Floors should similarly be carefully constructed. The ordinary plan is to provide wooden planks set about a foot above the cement and carried on beams. The space between the cement and the wooden floor should be amply ventilated by inserting layers of perforated bricks in opposite walls. The floor should be of a hard, well-seasoned wood, the planks forming it about four inches in width, tongued and grooved. Each board as it is laid must be clamped up in close proximity to its neighbour before being nailed to the cross beam. The disadvantage of this plan is that dust, possibly of an infectious character, gradually accumulates under the floor. Wood blocks set in tar laid upon the solid cement are now frequently used for school floors. They are often not so good as well-seasoned narrow planks, similarly set in tar or cement, as they present an excessive number of joints and are more apt to shrink and splinter than the best wooden planks.

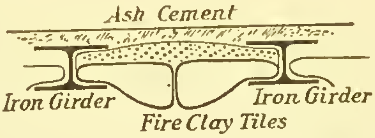

FIG. 17.—Showing fireproof floor.

If the building is of two or more stories the floors should be made fireproof. This is effected by using H-shaped iron beams instead of wooden beams. Special fire-brick tiles are then laid between the beams and the whole is covered with concrete made of ashes and cement: this cement is very strong and tough. The wooden plank flooring is then laid upon and nailed into this concrete, or wooden blocks can be used. The plaster which is to form the ceiling of the room below is not put on laths in the usual way, but on stout wire netting which is fastened to the beams. Such a floor is relatively incombustible and noiseless.

The floors of all lavatories and water-closets must be made of cement, asphalt, or terazzo, so that they can be sluiced with a hose. All the corners should be rounded off.

The Windows are very important. The glass area of the windows should be from one-fourth to one-sixth of the floor area. The sills of the windows for main lighting should be four feet above the floor and the tops should always reach to within six inches of the ceiling. No ornamentation is permissible which will interfere with the lighting, and the walls should preferably be cut away as in the diagram; when so cut away the whole of the glass area is available for lighting from whatever direction the light is coming. In the accompanying diagram it is quite evident how much of the light is cut off by square walls. A large portion of each window must be made to open; see chapter on "Ventilation" (p. 234).

The Doors may with great advantage be made to open both ways, and the street doors should be protected by a small outside porch in order that they may be constructed to open towards the street.

The Playground should be as large as possible. The Day School Code fixes the minimum as thirty square feet per scholar, and requires that the whole shall be properly enclosed, preferably with a low wall surmounted with high railings, in order to admit the maximum of sun into the ground. In mixed schools separate playgrounds should be provided for the two sexes. They should be on the sunny side of the school, *i.e.*, the south, or south-east or south-west. The floor should be even, and, of course, thoroughly drained. It is difficult to say of what material the playground should be made. Asphalt is clean, can be made and kept level, but is hard for falling. Gravel is loose, is difficult to keep level, and lends itself to being thrown about. Soil is impossible, because it sticks to the boots and makes the school dirty; and grass, even when it is available, is easily worn and objectionable in wet weather. One portion of the playground should be covered for wet weather; this may be accomplished by building a lean-to roof against one of the boundary walls—preferably against a north or east wall. The lower end of the roof should be supported on pillars so that the covered part is entirely open to the air. A basement is sometimes built with the lowest room rather less than half its height below the ground, and a portion of this used for a playroom in wet weather. Or the school is sometimes built on pillars about eight or nine feet above the ground, and the covered space thus left utilised as a covered playground. The great objection to both these plans is the comparative absence of sun in the covered playgrounds.

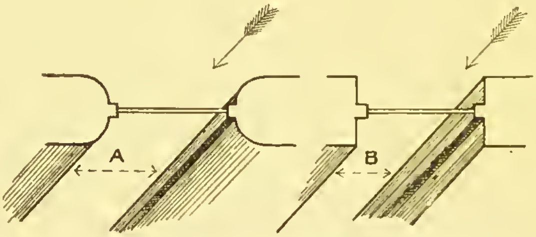

Fig. 18.—Showing effect of bevelling of windows on amount of light cut off from interior of room; A, width of completely illuminated part of room with bevelled windows; B, do., with ordinary square windows.

When the school site is limited in size a third practicable alternative to the above is to utilise the roof properly protected for this purpose.

CHAPTER XIX.

LIGHTING OF SCHOOLS.

LIGHT and happiness seem to be naturally associated and are even used as synonymous terms in the well-known verse, "Light is sown for the righteous and gladness for the upright in heart".

The depressing effect of a dull day, which depends largely upon the absence of direct sunlight, is felt by every one. No one is able to work continuously and well in a dull, badly-lighted room. As children are much more influenced by their environment than adults, it is not surprising that in dull, half-lighted schools the scholars are not so bright and receptive as in well-lighted schools.

The influence of the absence of light upon the physical condition is also great. The Spanish proverb "Where the light cannot come, the doctor must" is unfortunately too true. It is in dark and damp rooms that the germs of disease flourish, and in the dry and sunlit rooms that they languish. Of all taxes the most iniquitous was the old window tax.

Small windows, often half shaded by blinds, and seldom as clean as they might be, are defects common in old schools and present in some new ones. The general gloom is often increased by dark furniture and dark-coloured walls. In the "dull November days" in a school exhibiting these defects artificial light is used to brighten up the room, and this adds to the vitiation of the atmosphere.

The question of lighting may be considered under heads, 1. Natural, and 2. Artificial.

1. **Natural Lighting.**—Every effort should be made to have perfect natural illumination so as to avoid the use of artificial light except when, as at night, it is indispensable. In order to accomplish this, attention must be paid to several points, (*a*) the window area, (*b*) the direction of the light and position and size of the individual windows, and (*c*) the decoration of the walls and furniture.

(*a*) **The Window Area** must bear a relation to the floor-space. In a town, and especially when the school is in close proximity to other buildings, the window area should be *one-fourth* or *one-fifth* of the floor-space. In the country, or where the school is not and is never likely to be surrounded by other buildings, *one-sixth* of the floor-space may suffice. In buildings which are more than one storey high an amount of light which suffices for the second and third floors may be insufficient for the ground floor. It follows therefore that upper rooms must be over-lighted in order to ensure sufficient lighting on the ground floor. Excessive light can always be shut off by blinds ; insufficient light can only be augmented by artificial illumination.

The windows themselves should begin about four feet from the ground and should extend to the roof-plate. The sides should be straight and no ornamentation should be allowed to interfere with the entry of light through the windows. The space between adjacent windows should be small in order to prevent the bands of shadow which are cast across the school when windows are widely separated. Some recent schools have been built with iron pillars between the windows so that the space between the windows is little more than is necessary for the actual frames.

(*b*) **The Direction of the Light.**—It is generally found best to arrange the windows so that there are two sources of light, a main and a supplementary source.

The **main light** should come from the left of the scholars, so that, in writing, the shadow of the pen and hand is on the right side of the page. In order to secure this, the windows should be as broad as is consistent with the safety of the wall. By this means the shadows caused when a larger number of narrower windows is provided are to a large extent avoided.

The **supplementary light** will come preferably from behind, or from the right of the scholars, but must never come from in front of them. The windows through which this supplementary light is admitted should be smaller or less in number than those affording the main light.

The light should come on to the books from above downwards, and not horizontally. A horizontal light is liable to cause glare, but this will only occur in connection with windows having a sunny aspect. If the sills are four feet from the floor, and the desks about two and a half to three feet high, the light will slightly slope downwards. For the reasons given on p. 92 frosted or ribbed glass should not be employed. The window should never be shortened, so that the sills are more than four feet from the floor. Windows are very necessary for ventilation (p. 230).

The brightest light is that which comes through south windows. Direct sunlight has a wonderful power to destroy the germs of disease. The sun's rays, besides giving light, radiate heat, and during the summer months it is necessary to make provision against this excessive heat. This may be done by having white or drab outside canvas blinds, the bottoms of which, fastened to iron rods, fall outwards from the window. As the sun when it is hottest is highest, these blinds need not be made to fall so as to cover the whole window. (Fig. 19.)

A similar device may be used for shading the room from lateral rays of sunlight. Instead of the above method, inside slab blinds raised from below may be used, but these will cut off more light than the other form.

The rooms used for drawing should have their main light from the north, because this, although not as bright as a south light, is steady, and, therefore, the shadows are constant both in depth and position.

The windows used for supplementary lighting may have their sills as high as five feet above the floor, so that all the light falls down considerably; but they must not be too small, or efficient cross ventilation will not be possible.

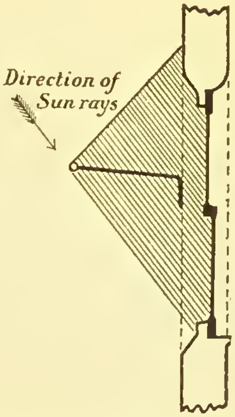

Fig. 19.—Showing how the sun's rays may be cut off without preventing entry of diffused daylight.

The proximity of other buildings, and the size of the school, may sometimes render it difficult to light the rooms as recommended above; or it may be necessary to make the best of an existing school originally wrongly planned.

If it be impossible to have a left main light, a right light should be secured; a main light from behind means that the scholars' books are always in the shadow of their own bodies. As already stated a main light in front of the scholars is never permissible.

An external wall so close to the school windows that it obstructs the light should be built of white glazed bricks; or, if already built, it should be whitewashed. Corrugated glass mirrors may be placed outside the windows to serve as reflectors.

If a basement room has to be partly lighted from a pavement, the paving is replaced by iron frames which carry a number of prisms of glass. The light falling upon the top of the glass is reflected by the prism into the room. (Fig. 20.)

Only when a sufficiency of light from the sides of a schoolroom is not obtainable are skylights to be used, and when these face in any direction except north they must have blinds to protect from the heat of the sun's rays in summer. These skylights are inconvenient on account of the direction of the light, and also because they are inaccessible and therefore difficult to keep clean (see also pages 92 and 300).

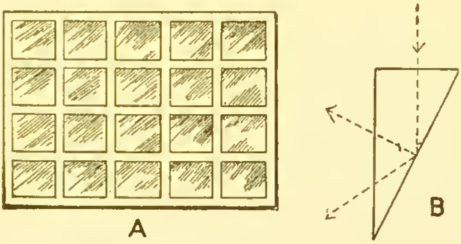

FIG. 20.

A, View from above. B, Lateral view of prismatic glass for lighting a basement.

(*c*) **The Decoration of the Walls and Furniture.**—It has been previously said that the walls should be smooth and impervious. The cement which lines the walls should be coloured of a light tint. By far the best colouring matter is paint because it is washable. The paint should be "flatted" so as to avoid gloss.

The best colour is light green approaching grey. The lower three feet of the wall should have a darker dado of the same colour to soften the light at the level of the scholars' eyes.

All the doors, cupboards and other fixed furniture should be of light wood, or should be painted with a light colour, not necessarily the same as the walls.

Any maps, charts, diagrams, etc., which are on the walls should also be of a light tint.

In gauging the lighting of a room it is necessary for the desk farthest removed from the source of light to be efficiently lighted upon a dull day. Many school days are dull days, and even on sunny days during winter the rooms are less bright than in summer. Hence the importance of regulating window area so as to meet the requirements for dull days (see also page 92).

2. **Artificial Lighting.**—Two points have to be considered concerning this: (*a*) the kind of light, and (*b*) its position.

(*a*) *Kind of Light.*—For general purposes the best source of light is undoubtedly electricity. It is usually steady; it lends itself admirably to shading, and it adds no products of combustion to the room.

If electricity is not available and gas must be used, only two forms of lamps are to be recommended, the incandescent mantle or the argand. An ordinary unprotected flame is influenced by every draught and therefore flickers. In some country places even gas is not available, and some kind of oil must be used.

(*b*) *The Position.*—There should be two separate sources of lights, one acting as a general illuminant, and the other serving to light the desks (see also page 92). The first should be placed well above the horizontal line of vision, and it is advisable, especially for incandescent gas lights and for the arc electric lights used in large drawing classes, to provide upward reflectors, ensuring that the general light reflected from the white ceiling is the chief source of illumination. It is impossible to provide by oil a bright diffuse light in a room. The second source of light should be distributed along the walls on the left of the scholars, supplemented by the light from above. The lateral lights should be placed at frequent intervals about five feet above the floor-level, so that the light descends from the scholars' left. It is to be noted that when gas is used, very efficient ventilation must be provided to remove the additional impurities from the room. This point will be alluded to in the chapter upon " Ventilation ".

CHAPTER XX.

THE NECESSITY FOR VENTILATION.

THE efficient ventilation of a school is the most important and generally the most difficult problem of school hygiene.

The usual conditions of civilised life, especially of urban life, involve many drawbacks. Persons leading a chiefly indoor life are never physically equal to those spending most of their time out-of-doors, and the continued massing together of people in large towns and the crowding of families in small, badly lighted, ill-ventilated houses involve the risk of producing a physically inferior race.

In the past there has been an unnecessary and in fact mischievous fear of fresh air. During the last few years this fear is happily disappearing. Much of the credit for the improved attitude towards ventilation is due to the crusade against tuberculosis; for the prevention and cure of which it is now known that an open-air life, both during hours of waking and sleeping, is indispensable.

The atmosphere in the open country has the following approximate composition :—

Oxygen	21 per cent.
Nitrogen and Argon . .	79 ,,
Carbon Dioxide (CO_2) .	0·04 ,,

There are also varying quantities of watery vapour and traces of ammonia, ozone, and organic matter. The amount of ozone is greatest in country places and at the seaside.

In and near towns certain deleterious gases are found, including sulphur dioxide and sulphuretted hydrogen ; but the main constituents do not perceptibly vary in amount. In the purest country air the amount of carbon dioxide is not above 0·035 per cent., and in the towns it is often about 0·04 per cent., and this difference is practically negligible.

The essential constituent of the atmosphere for all forms of life is oxygen, the nitrogen being inert and acting merely as a diluent for the oxygen. During all processes of combustion of organic matter—whether this takes place quickly as in a furnace, or slowly as in our bodies—carbon dioxide is formed by the combination of carbon with the atmospheric oxygen. If all living organisms constantly exhaled carbon dioxide, and it were not absorbed in some way, the atmosphere would in time contain an excess of it. Nature, however, has provided a means for the removal of any excess ; all green plants contain a substance called chlorophyll, which has the power in sunlight of splitting up the carbon dioxide into carbon and oxygen, the carbon being utilised to build up the plant, and the oxygen being returned to the atmosphere.

The amount of moisture present varies with such circumstances as the temperature of the atmosphere, the presence or absence of sun, the position in a valley or on a hill, the amount of wind, and so on. Low-lying tropical swamps are laden with moisture ; the slopes of high mountains are dry. On a wet day in summer the air contains a much greater amount of moisture than on a wet day in winter. The air also contains solid particles, consisting of mineral and organic matter blown about as dust, with which bacteria are frequently mixed. The chief harmful ingredients of air, both out-of-doors and in schools, are bacteria. In towns where dust and soot abound, the lungs of the inhabitants become very dark coloured, through the inhalation of these small particles. If the dust contained only particles of dead or inorganic matter, there would perhaps be no great danger from the inhalation, although it is certain that the inhalation of some kinds of dust—particularly that consisting of sharp, hard, mineral matter—is highly injurious. When, however, dust contains pathogenic bacteria the case is very different. The bacteria causing consumption are commonly present in the dust derived from the expectoration of people who are suffering from this disease. In towns it is in the dry dusty weather that attacks occur of what are known as common colds ; and when we consider the constitution of town dust this is not surprising. Solid particles, however small they may be, are heavier than the air, so that when the air is still, dust and bacteria are present only in small quantity, and only for a few feet above the level of the ground. The higher we ascend the purer the air becomes. With a fairly strong wind the dust is blown about and then is found at a considerable height. When rain occurs these small particles are washed out of the air, which then contains no dust and therefore no bacteria.

The Effect of Respiration.—Each time we inhale we take about thirty cubic inches (about three-quarters of a pint) of air into our lungs. The air enters the windpipe (trachea), passes down it and its branches (bronchi and bronchioles) into the infundibula or terminal air-cells of the lungs. These air-cells are lined with a very fine membrane, which easily permits of interchange of gases between the blood in the thin-walled blood-vessels around the air-cells and the air in these air-cells. If the air-cells were spread out the lining membrane would occupy a space of many square yards ; there is therefore a very large area from which the blood-vessels can absorb oxygen and into which they can discharge carbon dioxide. The result of this interchange is that the expired air differs very markedly from the inspired air.

Expired air contains only 17 per cent. of oxygen, that is 4 per cent. less than inspired air; and although under moderate conditions of crowding the air in a room might be re-breathed many times, the percentage of oxygen would not fall to such an extent as to render the air irrespirable from this cause until long after it had become noxious from other causes.

Expired air contains 4 per cent. of carbon dioxide (CO_2). In fresh air it is present to the extent of 0·04 per cent. Carbon dioxide is injurious when present in very large quantities, but in the proportion in which it is found in ill-ventilated rooms it may be regarded as innocuous. It is not until the air breathed contains 10 per cent. of *pure* carbon dioxide that poisonous effects are felt. When carbon dioxide is derived from respiration, the air containing it is poisonous when the percentage of CO_2 is much smaller.

Expired air is warmer than fresh air, and is saturated with moisture. The moisture is shown upon the cold window panes and wall surfaces on a winter's day. A damp atmosphere is not in itself necessarily harmful, though an atmosphere saturated with moisture feels distinctly oppressive. Scholars leaving a room with a too warm and humid atmosphere are very apt to suffer from colds (catarrhs), and such catarrhs in predisposed children may pave the way for consumption.

In addition to the above, the air of inhabited rooms contains traces of volatile organic matter given off by the bodies of the occupants. These organic particles and offensive gases may be derived from the skin, or from the alimentary canal.

Non-Respiratory Impurities in Rooms.—Besides the impurities caused by respiration and other vital processes, certain other impurities must here be considered. These arise from two sources, the stoves used for heating purposes, and gas used for illumination. When stoves are used they are sometimes overheated to such an extent that the iron may be made red-hot; under these conditions carbon monoxide (CO) may pass into the room through the iron. This gas is inodorous and therefore gives little warning of its presence. It is exceedingly dangerous, causing death even in small quantities. It combines with the hæmoglobin of the blood, and thus prevents the blood from carrying oxygen to the tissues. Short of fatal symptoms, CO produces giddiness and headache and impairment of the general health.

The products of the combustion of coal gas are carbon dioxide, water and small quantities of sulphur dioxide. The last-named is distinctly poisonous, and even in the small quantities in which it is formed in a room by the burning of two or three flames may produce a feeling of tightness in the chest. Coal gas is now frequently mixed with " carburetted water gas ". This contains 30 per cent. of carbon monoxide as against 6 or 7 per cent. in coal gas. With this mixture an escape of gas is fraught with much graver risk than is the case when pure coal gas is used.

The effects of breathing impure air may be immediate or remote.

The immediate effects of breathing the impure air found in an ill-ventilated schoolroom are drowsiness and languor, frequent yawning, inability to concentrate the attention, and slowness of intellectual effort. These results are not noticeable in the earlier part of the day when the air of the room is comparatively fresh. Good results cannot be expected when the brains of children are provided with blood poisoned by respiratory impurities.

When the space is totally inadequate for the occupants, and there is practically no ventilation, the immediate results are extremely disastrous. In the Black Hole of Calcutta, 146 persons were confined in a space of 18 feet every way, with two small windows on one side ; next morning 123 were found dead.

The remote effects of constantly breathing impure air are seen in the pale faces and sickly look of those who live in over-crowded rooms. These signs form an index of the debilitated condition of the whole system. As a result, an otherwise bright child becomes dull and apathetic. Not only so, but such a condition of debility renders the child much more prone than a healthy person to succumb to disease. Children are more susceptible than adults to the effects of impure air and the dangers which follow in their train; and too often the seeds of consumption are sown whilst the child is attending a badly ventilated school.

There is a further danger of impure air, and that is that in such an atmosphere the germs of disease will if introduced persist for much longer periods than in the open air or in comparatively fresh dry air. Colds, scarlet fever, diphtheria, spread more readily when the school air is foul.

Index of the Impurity.—The volatile organic matter which is probably the most injurious of all the ingredients of impure air is present in such small quantities that it is very difficult to estimate. The two ingredients, carbon dioxide and moisture, present in large quantity are, however, comparatively easy to estimate. It has been shown, moreover, that the quantity of carbon dioxide present is under ordinary conditions an approximately accurate index of the harmfulness of the air.

Fresh air, as we have seen, contains 0·4 parts per thousand of carbon dioxide. Air in a room which contains 0·6 per thousand is still fresh. There is a perceptible closeness when 0·8 per thousand, or 1·0 per thousand, is present. With 1·2 per thousand, or 1·4 per thousand, the air is disagreeable. In the latter case, that is when the carbon dioxide exceeds 1 per thousand, the moisture and organic matter, etc., are present in such a quantity that the air is harmful. In practice, therefore, whatever the actual source of danger, the carbon dioxide may be taken as the index. One per thousand is too low a standard, and, to ensure safety, the proportion of carbon dioxide should not exceed 0·6 per thousand.

Estimation of Carbon Dioxide and Moisture.

(*a*) **Carbon Dioxide.**—When carbon dioxide is shaken up with lime water, it combines with the lime and forms an insoluble substance, carbonate of lime, rendering the lime water milky. The amount of milkiness increases, *pari passu*, with the amount of carbon dioxide. In order to get an approximate idea of the amount of carbon dioxide in any sample of air, a series of bottles provided with glass stoppers is obtained: the largest 15½ ounces, and others 12½, 10½, and so on, to 2½ ounces (if the bottles are in cubic centimetres they vary from 70 to 430 c.c. capacity). The samples of air are collected by filling each bottle with water, and emptying it in the room which contains the air for analysis; as the water is emptied out, the air, of course, takes its place. The stoppers are then replaced. To estimate the amount of carbon dioxide, half an ounce (15 cubic centimetres) of lime water is carefully and quickly poured into each of the bottles, and the stoppers replaced as quickly as possible. The bottles are then shaken up well, so as to mix the air with the lime water. If milkiness appears only in the largest of the bottles (see the following table), there is not more than ·04 per cent. of carbon dioxide in the air.

The following table gives the approximate amount of carbon dioxide in the air:—

Bottle in which milkiness appears.		Carbon dioxide in air per cent.
15½ oz.	430 c.c.	0·04
12½ ,,	350 ,,	0·05
10½ ,,	290 ,,	0·06
9½ ,,	270 ,,	0·07
8½ ,,	240 ,,	0·08
7½ ,,	210 ,,	0·09
6½ ,,	180 ,,	0·10
5½ ,,	150 ,,	0·12
4½ ,,	130 ,,	0·14
3½ ,,	100 ,,	0·20
2½ ,,	70 ,,	0·30

(*b*) **Moisture.**—The moisture is easily calculated by means of wet and dry bulb thermometers. These are two ordinary thermometers fastened side by side upon a stand. Around the bulb of one a small piece of muslin about one and a half inches long is fastened and dips into a small vessel of water below the bulb. The muslin absorbs water and so moistens the bulb of the thermometer; the water evaporates from the bulb and thus abstracts heat from the bulb and mercury. The mercury in the wet bulb being thus cooler than that in the dry bulb registers a lower temperature. If the air in the room is dry, evaporation takes place quickly, and a correspondingly large amount of heat is absorbed from the mercury, and the difference between the two temperatures is considerable. If the air is already saturated with moisture, no evaporation can take place, and no heat is abstracted from the mercury; the read-

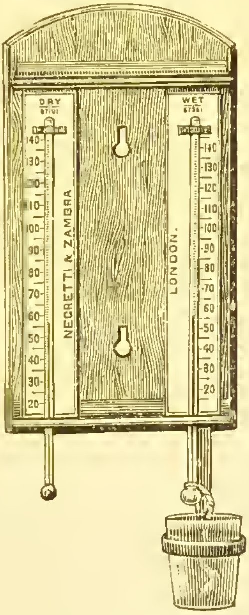

FIG. 21.—Dry and wet bulb thermometer.

ings of the two thermometers are therefore identical. The nearer the reading of the wet bulb thermometer is to that of the dry bulb, the more moisture is present in the air.

As a rule there should be a difference of between three and four degrees Fahrenheit between the two thermometers.

The temperature of the room being kept between 56° F. and 60° F.—the best temperature—efficient ventilation will keep the reading of the wet bulb thermometer between 53° F. and 56° F.

Determination of Deviation from Normal Air. (*a*) **Carbon Dioxide.**—An average adult takes about sixteen respirations per minute, and inspires and expires about 30 cubic inches at each breath. In an hour, therefore, he makes 960 expirations and exhales 960 × 30 cubic inches of air. The expired air contains 40 per thousand of carbon dioxide ; he exhales then

$$\frac{40}{1000} \text{ of } \frac{960 \times 30}{1728};$$

that is, 0·673 cubic feet of CO_2 per hour. A child exhales rather less than this, but owing to the greater amount of change that is taking place in his tissues the difference is slight. It is best to assume that each child exhales 0·6 cubic feet per hour.

(*b*) **Moisture.**—The expired air is saturated with moisture, that is, it contains as much as it is possible for it to contain in the gaseous condition. Without going into the details of the calculation, it may be assumed that each child adds to the air 225 grains of water per hour, or rather less than a tablespoonful. This does not perhaps convey so good an idea of the quantity as the statement that 500 children in the course of two hours give off as vapour over three gallons of water.

(*c*) **The Heat.**—The amount of heat which is given off by a child is by no means inconsiderable. If there were no ventilation in a room 12 × 10 × 10 feet and no loss of heat into the walls, etc., a child would in one hour raise the temperature of the air by about 6° F. It is not astonishing therefore that with forty or fifty children in a badly ventilated schoolroom the temperature soon reaches 70° F. or 75° F.

The Amount of Fresh Air Required.—The amount of fresh air required can now easily be calculated from what we know concerning carbon dioxide. In the following calculations it is assumed that the air in the room is always to be fresh, that is to say, the carbon dioxide must never exceed 0·6 per thousand.

In the first place, it is necessary to find out how long it would take to deteriorate fresh air containing 0·4 per thousand until it contains 0·6 per thousand of carbon dioxide.

Let us assume that each child is allowed a floor-space of 10 square feet, in accordance with the requirements of the English Code, and that the room is 12 feet high. Each child has, therefore, a cubic space of 120 cubic feet. In an hour a child exhales 0·6 cubic feet of carbon dioxide. The problem before us is to determine the number of cubic feet of carbon dioxide necessary to be added to 120 cubic feet of fresh air to make it 0·6 per thousand.

0·6 per 1,000 of 120 cubic feet is ·072 cubic feet.
0·4 per 1,000 of 120 cubic feet is ·048 cubic feet.

The difference is ·024 cubic feet. We now require to ascertain in what time a child will exhale ·024 cubic feet of carbon dioxide. As he exhales ·6 cubic feet in one hour $\frac{\cdot 024}{\cdot 6}$ of 60 minutes, *i.e.*, 2·4 minutes is required. *Thus with the floor-space insisted upon by the Education Code and with no ventilation the air of a schoolroom ceases to be fresh in two and a half minutes.* With double this floor-space, which is frequently given in high schools, five minutes would elapse before the air became unwholesome in the absence of ventilation.

The next question to be answered is, how much fresh air is necessary to keep the air of the school wholesome?

As the children remain in school for hours, the two and a half minutes during which no ventilation is necessary may be neglected. The problem, therefore, is to find how many cubic feet of fresh air are required to be mixed with 0·6 cubic feet of carbon dioxide so that this gas shall be in the proportion of 0·6 per thousand.

Fresh air contains 0·4 per thousand of carbon dioxide. The number of cubic feet necessary will be obtained by dividing the number of cubic feet expired per hour by the difference between the amount of carbon dioxide allowed (0·6 per thousand) and the amount of carbon dioxide present in fresh air (0·4 per thousand). The difference between these (0·2 per thousand) represents the amount of carbon dioxide which can be added by expiration before the limit of impurity is reached. As 0·6 cubic feet are exhaled per child per hour, and only 0·2 cubic feet can be added to the fresh air before the limit of impurity is reached, it follows that 3,000 cubic feet of air will be required per child per hour.

In the form of an equation, if x be the number of 1,000 feet of air required,

$$x = \frac{\text{amt. of } CO_2 \text{ exhaled per hour per child}}{\text{amt. of } CO_2 \text{ allowed} - \text{amt. of } CO_2 \text{ present}}$$

$$= \frac{\cdot 6}{\cdot 6 - \cdot 4} = \frac{\cdot 6}{\cdot 2} = 3.$$

In other words, 3,000 cubic feet of fresh air must be supplied to each child per hour.

If we allowed the very low standard of 1 per thousand of carbon dioxide the air would be vitiated in 5·2 minutes, and 1,000 cubic feet of fresh air would be required per hour per child to keep the air at this standard.

CHAPTER XXI.

NATURAL VENTILATION.

"IN[1] order to ventilate a room there must be provided (1) openings by which air may enter; (2) openings by which air may pass out; (3) a 'head' or motive power which shall cause the air to enter the inlet openings and to pass out of the outlet openings. The adequacy of the supply of air for the purposes of ventilation depends upon the provision and the due proportions of these three requisites. Each one of the three must be duly provided or the ventilation must necessarily fail. These I will therefore call the primary requisites of ventilation. For the adequate supply of air it is not indeed necessary that openings intended to be inlets should always be used for that purpose alone, a sufficient number of openings, any of which may function as inlets or outlets according to the circumstances of the moment, will satisfy the primary conditions of ventilation provided there is 'head' or motive power enough to drive a sufficient quantity of air through the openings.

"There are other conditions which should not be overlooked if the ventilation aims at being called successful, *viz.*, (4) the quality of the air supplied as regards freshness, cleanliness and temperature, having regard to its mixing with vitiated air without causing draughts. These I will call the secondary conditions of ventilation.

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[1] Report by W. N. Shaw, M.A., F.R.S., on the Ventilation and Warming in certain Metropolitan Poor Law Schools, 1898.

"In applying the terms primary and secondary to these requisites and conditions, I do not wish to express an opinion as to their relative importance or value in any particular case. If any *one* of the three primary conditions be not complied with, *i.e.*, if there be no inlets *or* no outlets *or* no head, ventilation does not exist; if all three primary conditions be fully satisfied, and either of the two secondary conditions be not complied with, there will indeed be ventilation adequate in quantity, but of such a kind that it might in some cases be regarded as producing a worse state of things than no ventilation at all."

When special apparatus for producing motive power is used to propel or exhaust air, the system of ventilation thus obtained is termed *artificial.* When on the other hand advantage is taken of forces already existing in nature without modification to produce the head required for ventilation, the system is termed a *natural* one. The latter only is considered in this chapter.

Air obeys the physical laws governing gases. It expands on heating; contracts on cooling; hot air rises to the top of a room and cold air descends to the floor; in flowing through pipes it is retarded by bends producing eddies, and by the friction caused by contact with rough surfaces. The influence of friction upon the passage of air is insufficiently appreciated, the builder frequently being allowed to line the ventilating shaft with rough bricks without even dressing the mortar, leaving it to protrude into the shaft.

Natural ventilation is produced in three ways, by diffusion, by convection, and by perflation.

Diffusion is the property possessed by a gas whereby it tends to spread itself equally throughout a space in which it is confined. If a heavy gas, such as carbon dioxide, be placed in the bottom of a jar and in the top a light gas, such as hydrogen, the two gases will after a time completely mix, the proportion of each in every part of the jar becoming exactly the same. This process is, however, slow, and is one which, in all problems of ventilation, may be neglected.

Convection.—When fluids or gases, such as air or water, are exposed to heat the particles in contact with the source of heat are first warmed by conduction. These particles being lighter ascend through the overlying strata, and in passing give up their excess of heat by conduction to the particles with which they come in contact. This movement of heated particles is known as convection. Not only do the currents thus produced mix the air in the interior of rooms ; they also cause an exchange between the outside and inside air. In an occupied room currents of air pass upwards from each person, first, because each person expires warm air, and secondly, because his body, being warmer than the external air, imparts heat to those particles in close proximity to him. As the warm air rises it warms the air above, and fresh air from the lower strata takes its place. When the warm air reaches the cold ceiling it imparts heat to it and

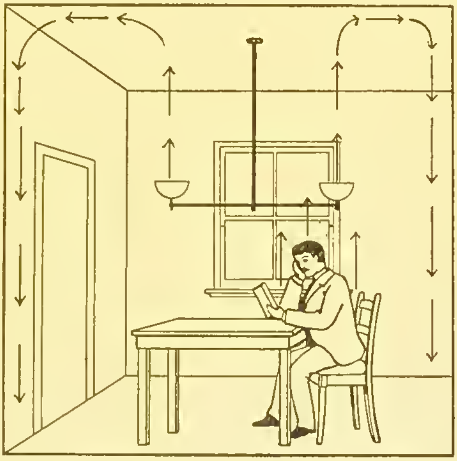

FIG. 22.—Showing convection currents from occupant of room and gas.

becomes itself cooled. Being colder than the air just below it, it descends, and in descending becomes warmed. Were there no ventilation, interchange would go on until the temperature of the ceiling, walls and furniture approximated to that of the occupant of the room. In an ordinary room the currents are upwards in the centre and downwards in the vicinity of the walls. The windows are generally cooler than the air in an occupied room, and therefore the air in their immediate neighbourhood is generally descending.

Soon the air in an occupied room becomes warmer than the external atmosphere, and convection currents are set up between the air inside and outside. If the window be open both top and bottom, the warm air of the room will pass through the top opening of the window into the open air, and fresh air will at the same time enter the room through the lower opening and descend to the floor.

The velocity of exchange will depend upon (1) the difference between the temperatures of the inside and outside air, and (2) the difference between the height of the inlet and outlet. The amount of exchange will depend upon the velocity of exchange and the size of the openings.

The velocity is calculated by means of the following formula :—

$$V = \sqrt{2gx(t^1 - t^2)af} \text{ feet per second,}$$

where g is the acceleration of gravity and may be taken as 32.

x is the difference in height (in feet) between the inlet and outlet.

t^1 is the temperature of the air inside.

t^2 is the temperature of thé air outside.

a is the coefficient of expansion of the air at t^2.

f is the coefficient of friction, and is generally assumed to be 0·75.

An example will serve to elucidate this formula.

The temperature of the air in a school is 65° F.[1]; that of the outside air is 50° F. The upper opening (top sash) of a ventilating window is 10 feet and the lower opening (bottom sash) 4 feet from the floor.

According to the formula

t^1 is 65°; t^2 is 50°; g is 32; x is 6 ft.; f is 0·75, and a is $\frac{1}{509}$.[2]

The formula is worked out as follows:—

$$V = \sqrt{2\,g\,x\,(t^1 - t^2)\,a\,f} \text{ feet per second,}$$

$$= \sqrt{2 \times 32 \times 6 \times 15 \times \tfrac{1}{509} \times \cdot 75}$$

$$= 2 \cdot 9 \text{ ft. per second.}$$

From the above illustration it will be obvious that the greater the difference in height between the inlet and outlet the greater will be the velocity of exit. (It is true that a greater difference between the temperatures will also cause an increased velocity, but in making calculations for proper ventilation this factor cannot be taken into consideration for two reasons; first, it would not be permissible to increase the temperature of the air in the school in order to increase the ventilation, and second, we have no control over the temperature of the outside air.)

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[1] Unless specially excepted all temperatures are given as degrees Fahrenheit.

[2] Gases expand $\frac{1}{491}$ of their volume at 32° F. (freezing-point) for every degree that they are heated. The absolute zero of temperature is therefore said to be 491° below freezing-point. In order to find the coefficient of expansion of air at any temperature, it is only necessary to add to 491 the difference between the observed temperature and 32, and place this number as the denominator of a fraction which has unity as the numerator. In the example the temperature 50° F. is 18° above 32°. The coefficient of expansion of air at that temperature is thus $\frac{1}{491 + 18} = \frac{1}{509}$.

Hence the outlet in a natural system of ventilation should be placed as near the ceiling as possible, and windows which extend to the ceiling will be more efficient ventilators than those which do not. A further reason for having the outlets at the top of the room is that the air at the top is the hottest and foulest and consequently most needs removal. Theoretically, the inlets should, when natural ventilation is in operation, be as low as possible. In practice, however, this plan cannot always be adopted ; if the inlets are placed at the level of the floor the cold fresh air, being heavier than the warmer air, runs along the floor. The scholars' feet are therefore exposed to a constant current of cold air. For this reason arrangements are often made, as by Tobin's tube, to allow the air to enter about 5 feet from the floor ; directly it enters the room it falls towards the floor, and thus mixing with the vitiated air is warmed before reaching the floor.

The amount of fresh air entering a room depends upon two factors, (1) the velocity of the air entering or leaving, and (2) the size of the inlets and outlets.

If the velocity is, as in the example on p. 227, 2·9 feet per second and the outlet is 1 square foot in area, it is obvious that 2·9 cubic feet will enter per second. We have previously seen that the least quantity of fresh air which can be allowed per child is 1,000 cubic feet per hour (page 222). The size of the inlets and outlets can therefore be easily calculated.

The velocity of 2·9 feet per second is equivalent to 147 feet per minute and 10,440 feet per hour. The size of the inlet and outlet must be therefore $\frac{1{,}000}{10{,}440}$ square feet, *i.e.*, about $\frac{1}{10}$ square feet. One hundred children would therefore require an outlet of 10 square feet, *viz.*, 4 × $2\frac{1}{2}$ feet. In winter, therefore, as in the preceding example, when the external temperature is 15° lower than the internal temperature, the openings need only be small. Remembering, however, that the internal temperature should not be above 60° F., and that only in a small part of every year the external temperature is as low as 45° F., it is clear that $\frac{1}{10}$ square foot will be totally insufficient during the greater part of the year. If, for instance, the external temperature is 55° and that of the school—as it should be—60°, the velocity calculated from the formula will be 1·6 feet per second, and the size of the inlet required per child $\frac{1}{3 \cdot 8}$ square foot, or 25 square feet for 100 children.

In order to allow for all contingencies, about 72 square inches should be allowed, *i.e.*, $\frac{1}{2}$ square foot for inlet and $\frac{1}{2}$ square foot for outlet, for each child. The outlets should be as near the ceiling as possible, and the inlets about 5 or 6 feet above the floor. As far as possible both inlets and outlets should be distributed over the walls of the schoolroom. Thus twenty-five inlets, each of 1 square foot, distribute fresh air more uniformly in a room than one inlet 25 square feet in area. This is subject to the general law that the friction of air passing through openings is inversely to the diameter of the openings.

To prevent down draughts the opening of each inlet is guarded by a flap fastened to its bottom and allowed to fall forward, so that the incoming air is given an upward direction.

Perflation.—Although much time has been spent in describing the part which convection plays in ventilation, it is upon perflation or cross ventilation that an efficient natural system chiefly depends. Owing to convection currents the external atmosphere is nearly always in movement, producing winds. When the wind impinges against one side of a school, the whole of the elaborate arrangements for the ventilation of the room by convection may be upset, the openings upon the windward side becoming inlets, and those upon the leeward side outlets. With a mild breeze (about two miles an hour) perflation is insufficient to ventilate the room, and yet the operation of inlets and outlets of air for convection is disordered.

The ventilation of a school by perflation cannot be solely trusted, because the force and direction of the wind cannot be controlled. Arrangements should, however, be made by distributing openings as much as possible in every outside wall, so that in whatever direction the wind blows some of the openings will act as inlets and some as outlets. It is with a view to ventilation by perflation that it is advisable to have the subsidiary light on the right of the scholars (p. 207).

Ventilation by perflation is necessarily applicable only to a certain extent. If the wind is not of sufficient force perflation does not occur, for although the wind may enter the openings on one side, it does not possess sufficient impetus to drive the air in the room through the ventilating openings for exit of foul air on the opposite side of the room. For perfect perflation to take place the wind must be blowing at the rate of six miles an hour, and at right angles to the walls containing the openings. If the wind be not blowing at right angles to the wall containing the openings, a greater rapidity of current is necessary; and the more nearly parallel the direction of the wind is to the wall, the greater must be the rate of movement of the wind.

Thus, although under favourable circumstances a schoolroom can be ventilated by taking advantage of currents of air in the school and outside, in actual practice but little ventilation takes place during the greater number of the days in each year, owing to winds blowing in the wrong direction or with insufficient force, unless both windows and doors are kept open.

Hitherto only the primary conditions have been considered; when the secondary conditions are brought under consideration the defects of natural ventilation become still more obvious. The air which comes into the room is not under control; but is admitted, however cold, damp or foggy it may be. The impossibility of thoroughly mixing fresh with vitiated air without causing draughts generally leads to closing of inlets in order to prevent discomfort, with the result that no ventilation occurs.

From the preceding considerations it is clear that the *maximum bonum* in natural ventilation unless both windows and doors are wide open is the dilution of bad with good air; while, as we shall see later (page 242), the *maximum bonum* of artificial ventilation is the steady replacement of bad by good air.

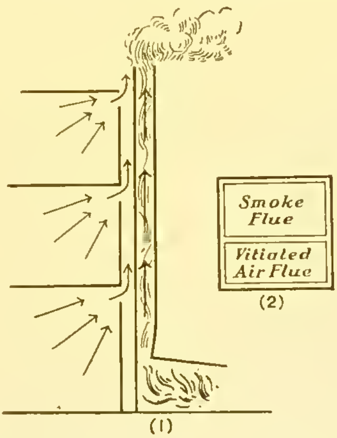

Fig. 23.—(1) Elevation; (2) section of double flue.

Hitherto no mention has been made of heating the schoolroom, and the effects of this upon natural ventilation. An open fireplace is a powerful aid to ventilation, and will be spoken of in the chapter upon "Artificial Ventilation" (p. 242). Some schools are warmed with hot-water pipes, having this as their sole function. These pipes, as well as open fireplaces, may, however, be made valuable adjuncts in ventilating a schoolroom.

In Fig. 23 the chimney has built alongside it separate flues[1] for carrying off foul air from each room. *A* is the smoke flue; as the hot smoke flows to the top of the chimney the independent vitiated air flues *B* become warmed and the air in them begins to flow upwards.

Hot-water pipes may be utilised to warm the incoming air. If the inlets are at the level of the floor the children's feet will be constantly subjected to a cold current. If, however, the air is made to pass over the pipes, not only will it be warmed and its circulation through the room promoted, but the children will be less likely to have cold feet.

No mention has as yet been made of the actual construction of inlets and outlets. It has been already suggested that they should be numerous and small, rather than few and large. The actual number and size of the openings must be regulated by the number of children who will occupy each room, allowing half a square foot of sectional area of opening for inlet and the same amount for outlet for each child.

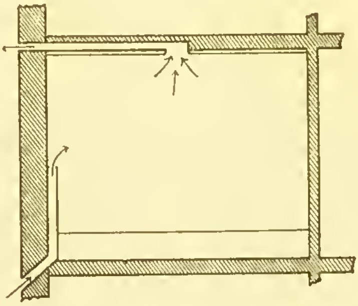

FIG. 24.—Tobin's tube and outlet ventilator through ceiling.

The simplest form of inlet or outlet is a hole through the wall at right angles to its surface. This must be lined with smooth cement to diminish friction for the incoming air, and to aid cleansing. Its outer end is protected by a grating. The size of the inlet is gauged by the free air-space of the grating and not by the size of the entire aperture. The grating must be both safely fixed and easily movable, as it requires to be cleansed at frequent intervals and the accumulated dust removed.

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[1] From the diagram it may be inferred that there is only one vitiated air flue. In actual fact each vitiated air flue, like each smoke flue, must be carried up to the top of the chimney stack separately from all other flues if back currents are to be avoided.

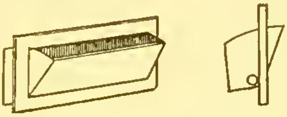

FIG. 25.—Sheringham's valve.

The inlets may have one of several contrivances at its inner end to direct the current of air upwards and across the room.

Special arrangements or apparatus for assisting ventilation are extremely common. The following are a few of the better-known forms:—

Tobin's Tubes.—These allow fresh air to be taken from at or below the level of the floor of the room and discharged into the room 5 to 7 feet above the floor. The cold fresh air receiving by this means an upward direction enters the room and mixes with its impure air without causing much perceptible draught. The tube should be circular in section, and the angle between the external aperture and the vertical tube as obtuse as possible. (Fig. 24.)

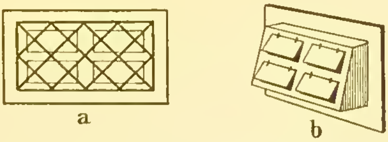

FIG. 26.—Boyle's mica flap outlet ventilator; *a*, view from room; *b*, view from chimney.

Sheringham's Valve is an arrangement by which the flow of air through the opening in the wall can be regulated at will. (Fig. 25.)

Boyle's Mica Flap is useful in removing some of the foul air from the top of the room into the chimney (Fig. 26); but a better plan is to provide a separate foul air flue as shown in Fig. 23.

The Windows may have contrivances to allow the fresh air to enter in a certain direction; for instance, if the bottom sash has placed under it a wooden guard about 2 inches high and the lower sash is brought down on to this, air enters the room with an upward direction between the sashes.

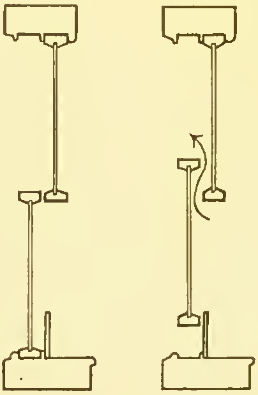

FIG. 27.—Hinckes-Bird window ventilator.

Many such contrivances are applicable to small rooms with a certain amount of benefit, but the smaller the opening the greater must be the rate of flow, and a perceptible draught is felt if air is entering a room with a temperature 10° F. below that of the room at the rate of more than 3 feet per second.

One or other of the three primary requisites mentioned at the beginning of this chapter are commonly missing in schools ventilated by natural means. Quite commonly inlets or outlets are provided, but not both of these. The comparative merits of natural and artificial ventilation and the comparative results of teaching in each of them are described on pages 258 and 260. It must be added, that this comparison is between natural ventilation as ordinarily carried out, and the best systems of artificial ventilation. It is conceivable, though improbable, that a natural system of ventilation might be successful even in a large elementary school. To ensure this, it would be necessary to keep doors and windows wide open so as to permit of free perflation, the temperature of the room being kept up as far as practicable by hot-water pipes and open fires. Most teachers and scholars would not tolerate such *widely open* doors and windows unless warmly clad and well fed. Given these conditions, the exposure to large currents of fresh cold air would be beneficial.

CHAPTER XXII.

WARMING OF SCHOOLS.

IT has been shown in the last chapter how impossible it is to provide efficient ventilation in a school by natural means. There is practically no satisfactory method of artificial ventilation which is not intimately connected with the particular method of warming employed. In some cases both functions are performed by the same mechanism, as happens, for example, when warmed fresh air is propelled into a room ; in other instances advantage is taken of the heating arrangements to produce the "head" necessary for ventilation, as occurs when an open fire is used.

Until the subject of warming has been thoroughly examined, therefore, it will be convenient to postpone the consideration of artificial ventilation.

Heat is distributed in three different ways : (1) By conduction ; (2) by convection ; and (3) by radiation.

Conduction.—This is the method by which heat is transmitted through solid bodies. If one end of a copper rod be heated in the fire the other end will soon become hot. Copper is, therefore, said to be a good conductor of heat. If a glass rod, on the other hand, be so heated, the end which is in the fire may actually melt, yet the rod 2 or 3 inches from the fused end will be scarcely warm. Glass is, therefore, said to be a bad conductor of heat. Conduction is, again, exemplified in the different sensations experienced when the hand is alternately placed upon pieces of wood and metal, both of which are at the same temperature. The metal appears to be colder than the wood, because being a good conductor the metal abstracts heat from the hand and quickly passes it away from the surface in contact, whereas wood being a poor conductor does not readily transmit the heat abstracted from the hand away from the surface. In the warming of a room conduction plays a very minor part.

Convection is thus explained by Clark Maxwell: "When the application of heat to a fluid causes it to expand . . . it is thereby rendered rarer than the neighbouring parts of the fluid; and if the fluid is at the same time acted on by gravity, it tends to form an upward current of the heated fluid, which is, of course, accompanied by a current of the more remote parts of the fluid in the opposite direction. The fluid is thus made to circulate, fresh portions of fluid are brought into the neighbourhood of the source of heat, and these, when heated, travel, carrying their heat with them into other regions. Such currents caused by the application of heat, and carrying their heat with them, are called convection currents. They play a most important part in natural phenomena by causing a much more rapid diffusion of heat than would take place by conduction alone in the same medium if restrained from moving. The actual diffusion of heat from one part of the fluid to another takes place, of course, by conduction;[1] but on account of the motion of the fluid, the isothermal surfaces are so extended, and in some cases contorted, that their areas are greatly increased, while the distances between them are diminished, so that true conduction goes on much more rapidly than if the medium were at rest."

Radiation.—When a solid body, such as a piece of iron, is heated in a hot fire, it becomes white-hot and emits luminous rays. When removed from the fire the mass of iron soon presents a dull red colour, and finally is invisible in the dark. Long after it has ceased to be luminous it continues to give out rays, which can be easily felt as heat by the hand, or registered on a thermometer. The heat, like the light, is conveyed from the hot iron to the cooler hand by radiation. Heat rays resemble light rays in many respects. Heat rays pass through many substances, just as light rays pass through glass. Such substances are said to be diathermanous. A substance which is absolutely diathermanous allows the rays to pass through it without itself becoming heated. Air is not strictly diathermanous, but the amount of heat taken up by the air is so small, that for practical purposes we may say that the air remains unaffected.

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[1] That is, that one molecule of the fluid is heated by contact with another, which is hotter than itself.

A schoolroom may be heated in three ways: (1) by means of a fire; (2) by means of hot pipes; and (3) by means of hot air.

1. Heating by Means of a Fire.—The usual method of heating small living-rooms in this country is by means of an open fire. The coal in burning becomes hotter than the room, and the heat, radiated from the hot coals, warms the furniture of the room. The heat acquired in this manner varies inversely as the square of the distance from the source; thus, if two pieces of furniture were placed 3 feet and 6 feet respectively from the fire, the amount of heat received by the latter would be $\frac{9}{36}$, or $\frac{1}{4}$ of that received by the former. As the furniture becomes warm, the molecules of air in contact with it are warmed and ascend, setting up convection currents. The whole of the products of combustion of the coal, together with much heated air, ascend the chimney and are lost to the room. It will thus be seen that the greater part of the heat produced by the combustion of the coal is lost; it is calculated that only about $\frac{1}{10}$ is available for heating the room. Heating by an open fire is, therefore, extremely wasteful.

It is quite impracticable to heat a large schoolroom by such a fire, because in order to have any appreciable effect upon the temperature of the room, the fire must be so large that the children in its immediate neighbourhood are scorched, whilst the opposite side of the room remains almost unwarmed. An open fire adds no products of combustion to the room, all these disappearing up the chimney. It, however, increases the dust in the room.

Instead of a fireplace a closed stove may be used. A stove gives far more heat per unit of coal burnt than an open fire, because not only does the stove radiate heat from every side, but it warms the air immediately adjoining it, and thus gives rise to convection currents. Further, if the stove-pipe itself is in the room this also serves as a source of heat.

The objections to a stove are that : (1) As the air of the room is heated it becomes drier: this can be overcome to some extent by placing a bowl of water upon the stove in order to add water vapour to the room ; and (2) in a cast-iron stove the iron sometimes becomes red-hot, and carbon monoxide (CO) may then escape into the room (see p. 215). This does not occur when the stove is properly lined with fire-clay.

2. Heating by Means of Pipes.—When pipes or hot air are used, the furnace, which is the original source of heat, is not in the schoolroom, but generally in the basement ; such methods are included under the term " central heating ".

The pipes may carry hot water or steam. The hot water may be either under low or high pressure. In a low-pressure system the water is heated in a boiler, and thence circulates through the pipes. A comparatively large quantity of water is used, and the pipes vary from 2 to 4 inches in diameter. The result is that a considerable time elapses before the pipes become hot, and once hot they take a long time to cool, because of the large volume of water heated.

In a high-pressure water system the pipes are not more than 1½ inches in diameter, and instead of a boiler a coil of the pipes is made to surround the furnace. This system becomes hot more quickly because the total volume of water is less, and the water is brought into closer relation with the furnace. Consequently it can be maintained at a considerably higher temperature than is possible in the case of a low-pressure system.

Steam when used is generated in a boiler, and is supplied to the pipes therefrom, the condensed water from the pipes being returned to the boiler.

When pipes containing hot water or steam are used, the room is heated partly by radiation and partly by convection. The distribution of the pipes is important and will be discussed later (p. 246). It is only necessary to state here that no system of heating by pipes can be recommended which does not at the same time aid in the ventilation of the room (see p. 245). The old system of having two hot-water pipes traversing the schoolroom alongside the walls is most unsatisfactory, for although the room is warmed, the effect *re* ventilation is merely to increase convection currents *in* the room, without aiding the removal of foul air from the room or the warming of incoming fresh air. Such a system necessarily implies hot, stuffy rooms and unsatisfactory work.

3. Heating by Means of Hot Air.—This method consists in projecting heated air into the room. The old method of accomplishing this was to have an iron furnace below the floor encased in a large iron box connected both with the outer air and with the room. The hot air was allowed to enter the room through gratings in the floor. The disadvantages of this method were so great that it has fallen into disuse. The air delivered was very hot and dry, and often had an unpleasant odour from the charring of particles of organic matter contained in the air. Further, it was found very difficult to distribute it so that it entered the room at many points, and consequently the room was not effectively warmed.

A thermometer should be placed in every class-room, the most suitable temperature being 60° to 65° F. Care should be taken that the thermometer is in a suitable part of the room, not directly in front of a fire, or over the mantelpiece, or near an open door.

Having described the methods of warming it is now convenient to discuss the problems of artificial ventilation which are in the main dependent upon effective warming.

CHAPTER XXIII.

MECHANICAL VENTILATION.

FREEDOM from damp and good ventilation are the most important requisites in a school. In actual practice it commonly occurs that while many thousands of pounds are spent in the erection and decoration of a school, a trifling and altogether inadequate sum is devoted to its ventilation, or provision for this may be entirely ignored.

To secure an efficiently ventilated schoolroom, neither money nor care must be spared. The cheapest efficient system is comparatively costly, both to instal and to run. The best artificial system will not give good results unless intelligent supervision is exercised.

It will be convenient to treat of artificial ventilation according to the method of heating.

An **open fireplace**, containing an ordinary fire, removes about 14,000 cubic feet of air per hour ; at first sight, therefore, such a fire in a small room might be considered a valuable means for securing good ventilation. In practice this is not so. The air passing up the chimney is derived from the lowermost layers of the room, and these are usually the purest. The foul air, being warmer, ascends to the ceiling, and is practically unaffected by the draught up the chimney. It is true that the flow of air towards the chimney sets up currents which help to mix the good air with the bad, but the admixture is so slight that a person seated on a chair may be breathing foul air, while his feet are exposed to the draught of pure, cold from the door to the chimney.

An open fireplace in a small classroom may, nevertheless, be made a valuable adjunct to ventilation by the use of certain devices. One of the best of these devices is that of Galton, and depends upon the utilisation of the heat of the products of combustion going up the chimney. A chamber is placed behind the chimney, communicating at its lower end with the open air, and at its upper end with the room, by an opening over the mantelpiece. When the fire is alight, the air in this chamber is heated, and, therefore, rises into the room. Here it mingles with the fouled air; so long as the fire is alight, fresh air will continue to be delivered into the room, warm and above the breathing line. Moreover, as air is entering in this manner, less enters under the door and windows, and there are therefore fewer cold draughts. In such ventilating fireplaces, the lower the point of entry of the warmed air, the more complete is the admixture with the air of the room.

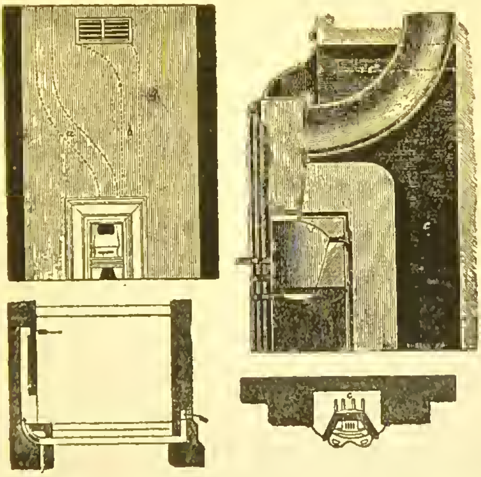

FIG. 28.—Galton's ventilating stove. *a*, smoke flue; *b*, air flue; *c*, air chamber.

If an opening is made near the ceiling into the chimney, or into a flue which runs alongside the chimney (p. 231), a fair amount of ventilation may be secured. If made into the chimney, the opening should be guarded by a mica valve to prevent down draught (Fig. 26). The constant flapping of this valve is extremely irritating. Furthermore, the flap is liable to act imperfectly, and then admits smoke into the room.

A Closed Stove.—Of ventilating stoves there is an almost endless choice. The principle involved in all is, however, the same. The stove and its flue serve to warm the air in their immediate neighbourhood, and, as this air rises into the room, it makes room for fresh air, which is in turn heated, and enters the room. Examples of these are Bond's Euthermic Stove, and George's Calorigen Stove. Instead of burning coal or coke, these stoves may be heated by gas. It will be seen in the diagram that there can be no possible connection between the incoming fresh air and the outgoing products of combustion. If the flue pipe, instead of going through the wall at the level of the stove, be carried up to the ceiling, and an opening

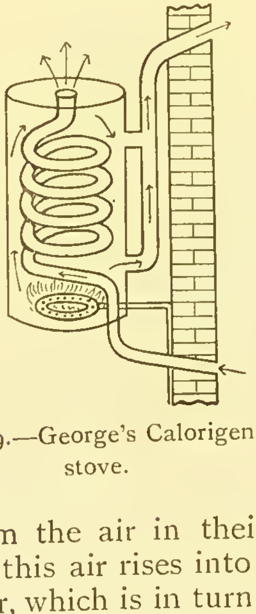

Fig. 29.—George's Calorigen stove.

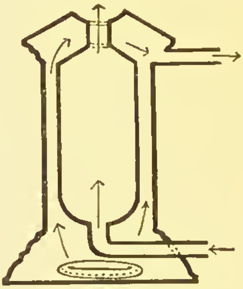

Fig. 30.—Bond's Euthermic stove.

leading to an outer wall made in the ceiling for the exit of the foul air, the hot pipe passing through it will aid considerably in securing good ventilation. Such a stove must never be used in a room unless there is an effective outlet, and care must be taken that all the joints of the stove are perfectly air-tight, so that none of the products of combustion can gain access into the room.

Hot Water or Steam.—It has been previously stated (p. 240) that no system of heating should be adopted which does not aid ventilation. When a schoolroom is too large for a stove or open fire—and this is the case when it is large enough to accommodate about thirty pupils—both warming and efficient ventilation can be secured by a judicious distribution of the pipes.

When the pipes are gathered together in stacks or radiators, distributed about the room, the heating is termed *direct*; when the radiators are hidden and the hot air is led into the room from them, the method is known as *indirect*; when the radiators are actually in the room but also warm the fresh air as it is admitted into the room, the method is known as *direct-indirect* or *semi-direct*. The direct method should never be employed alone, for reasons already given (p. 240). The essential difference between the indirect and direct-indirect methods is that in the former warming and ventilation are both secured together, in the latter the warming is made to assist the ventilation.

The Direct-Indirect or Semi-Direct Method.—In considering these methods of ventilation Shaw's requisites must be borne in mind (p. 223). These are (1) inlets, (2) outlets, (3) motive power or head, and (4) quality of air.

1. Inlets.—The position of the inlets and radiators should be so regulated that the full amount of air necessary should enter at a small velocity (not more than about 5 feet or 6 feet per second), and all the entering air should pass through the radiator. In view of these requirements the number of inlets should be more than is usually allowed, and the radiators connected with them should be of smaller dimensions than usual. In a room 40 × 30 × 12, for forty-eight scholars 144,000 cubic feet of fresh air per hour would be required, and in order that the air should not enter at more than 6 feet per second, 7 square feet of inlet would be necessary. Four radiators each covering inlets of 2 square feet would therefore suffice.

There are various ways in which the air may be made to pass the radiator, as illustrated in the diagrams on the opposite page.

The simplest form is seen in Fig. 31, where a hole in the wall is directly opposite the radiator, which is not enclosed. The air passes in horizontally towards the radiator, and as it becomes warm takes an upward direction. In Fig. 32 (Keith's "Aiolian" radiator) the air enters from the floor, and, therefore, has from the first an upward direction. In Fig. 33 the lower portion of the radiator is encased, so that although the air enters behind the radiator horizontally, it is forced to take a diagonal course in front of the radiator.

The inlet ventilating gratings should be fixed flush with the external face of the wall, and should be provided with wire gauze for the reasons already given (p. 233). As in an artificial system of ventilation the inlets are really in constant use, they more readily become dirty than do the inlets of a natural system. Arrangements must therefore be made to ensure that they can be cleansed with ease. There is some difference of opinion as to the advisability of making arrangements to close the inlets, when too large a volume of comparatively cold air is entering. In our opinion the inlets should be always open, the amount of air entering being regulated by adjustment of the outlets.

2. **The Outlets.**—The outlets as in natural ventila-

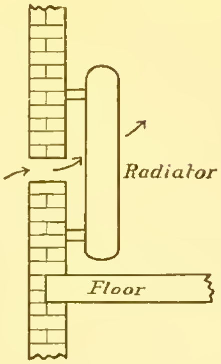

FIG. 31.

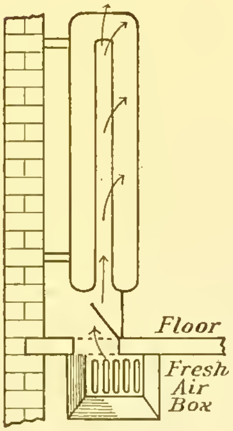

FIG. 32.

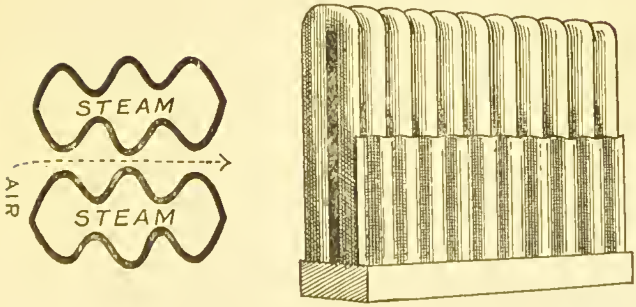

FIG. 33.

Forms of ventilating radiators.

tion must be placed in the semi-direct method of artificial ventilation at the top of the room. The necessary dimensions of the outlets depend upon the rate of exit of air. The available head producing the exit is determined by the temperature of the air. This will therefore also determine the necessary size of outlet required for a given discharge. The most lavish provision for the admission of fresh warmed air will fail if there be no adequate provision for the escape of impure air. The authors in one instance measured in the winter the amount of air entering a room having two inlets guarded by hot radiators but no outlets other than the windows and doors, and found that only 9,600 cubic feet of air were entering through both inlets per hour. As twenty people were in the room, the inadequacy of the ventilation is obvious.

3. The Head.—The motive power in this system of direct-indirect heating is applied at the outlet. The simplest method of producing a head at the outlet when gas is available is that usually employed in the fume chambers of chemical laboratories, a gas burner being lighted at the mouth of the outlet which consists of an iron pipe. In small rooms such a method may be adopted with success. In large rooms the amount of gas required to produce the necessary head would be so great that the expense would be serious. There is a further objection that the gas might be turned off or blown out and accidents result unless due vigilance were observed.

If steam is used for the radiators a coil or coils of pipes may be arranged to line the outlet shaft. If steam under pressure enters the pipes the air in the outlet shaft becomes heated to over 100° C. (212° F.), and, therefore, rises into the open air with a very considerable velocity. This system has been found to work well. If hot water is used for the radiators the temperature will not be sufficiently high to give the necessary head.

The head may also be supplied by a *fan.* The necessary size and the rate of revolution of the fan can be easily calculated from the general rule that the velocity of air passing through the opening is three-quarters the velocity of the circumference of the fan.

In the example mentioned on p. 246 we have seen that 144,000 cubic feet of fresh air are required per hour; this amount of air must, therefore, be abstracted by the fan, *viz.*, 2,400 cubic feet per minute. Suppose the diameter of the fan is 3 feet, then since the sectional area is $\left(\frac{3}{2}\right)^2 \times 3{\cdot}1416$, or 7·0686 square feet, that is, approximately, 7 square feet, $\frac{2{,}400}{7}$ or 342 linear feet must pass the opening per minute. As the velocity of the air is $\frac{3}{4}$ that of the circumference of the fan, the fan must make $\frac{4}{3} \times 342 \times \frac{1}{3{\cdot}1416} \times \frac{1}{3}$, or forty-eight revolutions per minute. With a smaller fan a correspondingly greater number of revolutions will be required.

The fan may be driven either by steam or electricity.

Still another way of providing the necessary head is to connect the outlet with the chimney of the boiler.

4. The Quality of the Air.—Its freshness, cleanliness temperature and degree of moisture require discussion.

In the semi-direct method the freshness and cleanliness of the entering air are but little under control since it is drawn from outside through several openings, and it is difficult to keep the various openings free from dust.

The Temperature can be regulated with a considerable degree of accuracy if a skilled person is in charge. If water is used for heating, the boiler must be kept at such a temperature that the water in the pipes provides the necessary degree of heat. If steam is used it is impossible to have a lower temperature than 100° C. in the pipes, and the amount of steam passing through the radiators must be regulated. This may be accomplished by having the radiators divided into sections so that part of each radiator may be shut off at will. It is better to regulate the heat by shutting off part of each radiator than by shutting off some of the radiators altogether: as thus all the entering air will be uniformly warmed. The admission of hot air at one point and of cold air at another presents obvious drawbacks.

Moisture.—When, as in natural ventilation, unaltered outside air is introduced into the schoolroom, generally in insufficient quantity, the moisture in the schoolroom becomes excessive. In an efficient system of artificial ventilation, unless precautions are taken, the air becomes too dry.

In this country, except on foggy or rainy days, the atmosphere usually contains about 75 per cent. of the aqueous vapour required to saturate it. The amount of aqueous vapour which the air will take up depends upon the temperature, but the actual amount is not so important as the percentage of the saturation amount. When at any temperature the air contains as much water vapour as it can hold without depositing it in the form of dew, it is said that the "relative humidity" is 100. On a cold winter's morning in a room in which no fire has been lighted the windows are covered with moisture or hoar-frost. When the fire is lighted this gradually disappears, owing to the fact that as the temperature of the room rises the air is able to contain more water vapour, which is evaporated from the visible moisture on the window pane. Air at 42° F. can contain when saturated exactly half the amount of moisture required to saturate it at 61° F. If, therefore, the outside air at 42° F. had a relative humidity of 75 per cent., and were heated (in order to ventilate a school) to 61°

F., the relative humidity of the air in the school would be reduced to one-half of 75 per cent., or 37·5 per cent.

The farther removed air is from saturation the more readily will it take up moisture. When scholars are in a room warmed by such dry air, there being more moisture in their bodies than in the boards, desks, etc., they give out moisture to these inanimate objects. This abstraction of moisture is evidenced in many ways as by dry skin, and increased tendency to throat troubles, such as chronic catarrh, and so on. Scholars on leaving such a school, are exposed to the danger of suddenly changing from a warm dry school to the cool moist external air. It is therefore desirable to ensure the sufficient moisture of the air.

In the example on p. 246 we found that 144,000 cubic feet were entering the school per hour. If this volume of air were at a temperature of 42° F. before heating, and had a relative humidity of 75 per cent., then the evaporation of no less than 34⅔ gallons of water would be required for the forty-eight scholars during a working day from 8 A.M. to 4 P.M.

This evaporation may be effected by placing vessels of water upon each of the radiators. The small bowl of water often seen alongside a radiator is utterly absurd. The amount of vapour required and the method of obtaining it can only be found by taking the readings of the wet and dry bulb thermometers, reading off from tables the relative humidity and calculating the amount of water required (p. 252). The moisture produced by the exhalations from the occupants of a room does not enter into the problem in the semi-direct system of ventilation as it is being steadily removed. The following table shows various relative humidities from 75 per cent. to 50 per cent. when the dry bulb is from 56° to 60° F. The relative humidity should never be allowed to sink below 55 per cent., so that, as will be seen by the table, there should never be a difference of more than 9° between the two readings when the air in the room is at the optimum temperature, *i.e.*, between 56° and 60° F.:—

Reading of Dry Bulb.	Reading of Wet Bulb.	Relative Humidity.
Degrees F.	Degrees F.	Per Cent.
56	51·8	75
	50·8	70
	48·8	65
	48·7	60
	47·7	55
	46·1	50
57	52·7	75
	51·7	70
	50·3	65
	49·6	60
	48·6	55
	47·7	50
58	53·7	75
	52·7	70
	51·6	65
	50·6	60
	49·5	55
	48·2	50
59	54·7	75
	53·7	70
	52·2	65
	51·5	60
	50·5	55
	48·9	50
60	55·7	75
	54·6	70
	53·6	65
	52·5	60
	51·4	55
	49·8	50

The Indirect Method.—In the indirect method of heating there is generally no apparatus for heating in the room. Occasionally a small fireplace or small radiator is placed there, but this is entirely subsidiary. The main heating is effected by warm fresh air. This method is most suitable to large rooms, or to buildings containing many rooms. In the latter case the advantage of having the whole of the heating and ventilation under one central control is obvious. It is true that for this method extra labour is required, and, therefore, extra expense entailed, but in view of the importance of efficient ventilation in school hygiene, and of the fact that when once the system is installed, the extra cost per child in a large school is but trifling, this objection is reduced to a minimum.

The inlets and outlets are connected by pipes or conduits to a main inlet or outlet shaft or corridor. In the inlet corridor the heating and moistening of the air are effected. The previous remarks concerning the size and distribution of inlets (p. 245) apply equally in this case. It is better to have the air admitted and extracted at several points than at one point, since this ensures the proper replacement of the air and an even distribution of the heat.

The inlets should be placed about 8 feet above the floor; they should be covered with a wire screen of about 2-inch mesh to prevent foreign bodies becoming lodged in them and hindering the entry of air, and should never be provided with means of closure.

The outlets should be placed about 6 inches above the floor.

The relative position of the inlets and outlets given above is based on a series of experiments which show that when the inlets and outlets were in this position the best exchange was effected. The following diagrams show the ventilating effect when the inlets and outlets are in various positions, the results being identical in both exhaust and plenum systems. The shaded parts show the foul air, the light parts the fresh air. The dotted line indicates the breathing line, *i.e.*, the average height of scholars when sitting. The purest atmosphere is obtained with artificial ventilation when the inlet and outlet are on the same side of the room. (Fig. 34.)

The Head.—The head may be supplied by fans or by means of a furnace. A furnace serves only to extract foul air from the outlets. A fan may be used to extract foul air from the room or to propel fresh air into it. Two systems are, therefore, described, the "exhaust" and the propulsion or "plenum".

The Houses of Parliament are heated and ventilated by the exhaust system; in one of the four corners of the clock tower and of the Commons tower is a large chimney; at the bottom of this chimney a fire is kept burning; the air which feeds the fires comes through large conduits from the perforated roofs of the Houses; the fresh air taking the place of that extracted from the Houses enters through the floors, which are also perforated; the fresh air is led to the floor by conduits from the terrace on the river; in the course of its flow the air passes through a room containing a large num-

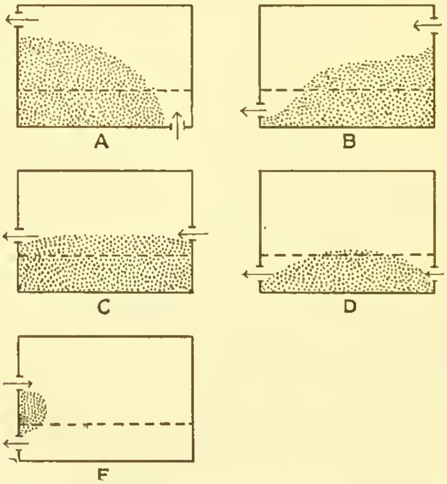

FIG. 34.—Showing in a combined "exhaust" and "plenum" system of ventilation the relative position of inlets and outlets of air giving purest air throughout a schoolroom.

ber of radiators, arrangements being also made in different parts of the conduit for moistening, for cooling, and, in foggy weather, for filtering the air.

Instead of by a furnace the air may be extracted by a fan or fans placed at the extremities of the outlet conduit.

In the plenum system the air is driven into the building by means of a fan. Propulsion fans differ in construction from exhaust fans owing to the greater pressure they have to overcome. In the exhaust system the rooms to be warmed and ventilated are situated between the radiators and the exhaust ; in the plenum system the room is the terminal, the fan being placed between the radiators and the room, or the radiators between the fan and the room.

The Quality of the Air.—With indirect heating the quality of the air can be more easily controlled than with any of the other systems, as the source of supply can be selected and its quality regulated.

Freshness.—The air should enter the conduit from a part most remote from habitations or streets.

Cleanliness.—The smuts and dust of town air may be removed in several ways. The air may be filtered through sieves of material of the texture of butter muslin: these soon become clogged up and require frequent renewal. Another method which at the same time serves to moisten the air is to use a sieve of hemp of ¼-inch mesh and to allow a slow stream of water to flow down the sieve. In foggy weather the air entering the Houses of Parliament is forced through layers of cotton-wool, large quantities of solid matter being retained by the sieve after it has been in use for a couple of days.

Temperature.—The temperature is regulated by steam radiators ; these are smaller than those used in the semi-direct method, and can be made with greater radiating surfaces, because being hidden it matters not if they are unsightly. With a comparatively large number of small radiators, each of which can be independently turned on and off, the temperature is regulated with comparative ease, and the air can be well mixed before being delivered. In summer weather the air may be cooled. In a school the conduits may be led through the basement which is usually cool because the sun's rays cannot get to it. Care must be taken that the conduits are made of impervious material with air-tight joints. The entering air may be passed over blocks of ice or through refrigerated chambers. The degree of cooling being regulated by controlling the amount of air subjected to treatment, the treated and the untreated air must be mixed before delivering in order to secure its delivery at a uniform temperature.

Moisture.—The proper degree of moisture of the air is secured by evaporating water from the radiators. It will be seen that even if saturated when drawn from the outside the air will not necessarily contain the proper amount of moisture when it is heated. Suppose the air is entering at a temperature of 42° F., and saturated; at this temperature the water vapour would give a tension of ·267 inches of mercury. If the air were heated to 60° F., in order to have a relative humidity of 75 per cent., the tension required would be ·388 inches, so that about half as much moisture would have to be added as was already present.

Precautions to be adopted when using the indirect method of heating.—When a room is heated by air the furniture and walls are heated by conduction: an open fire or a stove heats the furniture and walls by radiation and the air becomes warmed from them. There must, therefore, in the indirect method be a considerable loss of heat into the walls and furniture. This loss is very marked at the windows, and is so great when the temperature is low outside that those in the neighbourhood of the windows often experience a draught of cold air which appears to come through the window. In point of fact the window cools the air in the vicinity to such a degree that the latter falls to the floor with rapidity, giving the scholars near the window the impression of a cold incoming draught. This may be obviated by having double windows. The apparent draught is much less when plate glass is used instead of ordinary glass.

With both the plenum and exhaust systems of indirect ventilation the ventilation and heating are independent of incoming air from doors and windows. If these are not kept closed, cold air enters and sets up cross currents, thus interfering with proper warming as well as with efficient ventilation. With the plenum system it is not so imperative to keep doors and windows shut, as these will all act as outlets.

Both systems, however, may be partially upset in high winds. Reserve inlets are therefore advisable so that the air may, under these conditions, be drawn from the leeward side. With the plenum system it may then be necessary to close all the windward outlets, as the wind may be so high as to convert them into inlets, and the entering air will then be unwarmed.

Comparison between the Exhaust and Plenum Systems.—In the exhaust system the air is always slightly under the normal pressure. This is not disadvantageous from a hygienic standpoint. In the plenum system the air is under slightly increased pressure which may be slightly disadvantageous.

The great advantage of the plenum over the exhaust system is that the source of the air can be chosen and the quality of entering air controlled; in the exhaust system doors and windows all act as inlets, and therefore the source cannot be so thoroughly controlled, nor can the whole of the air be always treated. The best results of all appear to be obtained when the plenum system is adopted in conjunction with a subsidiary exhaust.

Advantages of Mechanical over Natural Ventilation.—The advantages of mechanical over natural ventilation have been demonstrated by many writers upon the subject of school hygiene, notably Carnelley. The results which he obtained from the examination of a large number of Scotch schools are given in the accompanying tables.[1]

AIR IN SCOTCH SCHOOLS.

	Natural Ventilation.				Mechanical Ventilation.		Total.
	Country Schools.	Suburbs and Country Towns.	Aberdeen Town Schools.	Dundee Town Schools.	Aberdeen Town Schools.	Dundee Town Schools.	All Schools (except Dundee).
Number of schools	28	14	17	19	3	4	48
,, ,, rooms	45	46	42	39	12	25	111
Cubic feet per person . .	148	160	138	168	155	164	—
Per cent. windows open . .	24	32	28	22	—	3	—
Temperature inside . .	60·1	60·5	58·5	55·6	55·3	62·0	59·7
Temperature outside . .	51·3	49·8	44·3	38·8	42·3	38·0	47·4
Vols. CO_2 in 1,000 (outside=3·1 . .)	16·1	16·7	18·0	18·6	12·3	12·3	16·3
Excess of organic matter . .	2·4	3·4	4·8	7·8	1·1	1·1	—
Bacteria per litre .	70·0	98·2	134·5	151·0	16·0	16·0	—
Moulds per litre .	5·6	4·4	1·5	1·1	0·6	0·6	—

When grouped according to the mode of heating:—

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[1] Carnelley, *Journal of Pathology*, Nov., 1893, and Kerr on "School Hygiene," *Journ. Roy. Statist. Soc.*, vol. lx., part iii., p. 23.

MODE OF HEATING AND SCHOOL AIR.

Mode of Heating.	Schools.	Rooms.	Cubic Feet per Person.	Per Cent. of Windows open.	Temperature.		Vols. CO_2 per 10,000.	Micro-organisms per Litre.	
					In.	Out.		Bacteria.	Moulds.
Mechanical ventilation by warmed air .	6	32	160	1·5	58·6	40·1	12·3	17·5	1·0
Natural ventilation and hot pipes . .	17	43	176	37·0	58·4	46·4	16·3	96·5	1·1
Natural ventilation and open fires . .	33	84	145	30·0	58·4	44·8	19·2	153·2	4·8

In the following table Professor Carnelley summarised the results obtained by him.[1] If the state under each item in the first column of the following table obtained in mechanically ventilated schools be taken as unity, then the comparative condition in naturally ventilated schools is as follows:—

Excess over Outside Air.	Dundee Schools (Carnelley, Haldane and Anderson).		Aberdeen Schools (Brazier, Thomson).	
	Mechanically Ventilated.	Naturally Ventilated.	Mechanically Ventilated.	Naturally Ventilated.
Temperature . .	1	0·66	1	0·9
Carbonic acid .	1	1·7	1	1·6
Organic matter .	1	7·0	—	—
Micro-organisms .	1	9·2	1	7·2

Dr. James Kerr, when medical officer to the Bradford School Board, obtained similar results, which are embodied in the following diagram. The diagram shows how the quality of the school air remains constant with mechanical, while with natural ventilation it steadily deteriorates as the school session proceeds.

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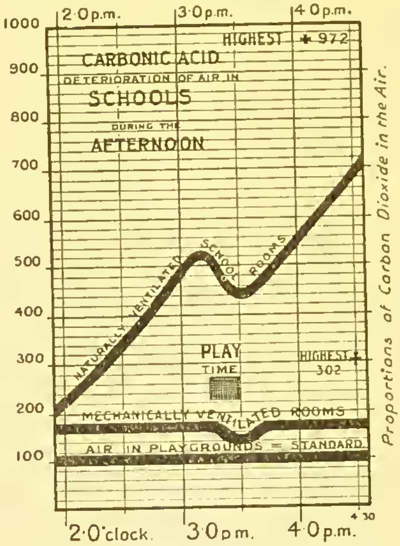
[1] "Report on the Cost and Efficiency of the Heating and Ventilation of Schools," by Professor T. Carnelley, D.Sc.



As the efficiency of a school depends so largely upon the admission of a sufficient supply of proper air, it will be anticipated that better educational results are obtained in schools which are mechanically ventilated than in those which are ventilated by natural means, and this fact has been demonstrated by the results of the examinations held by H.M. Inspectors.

Carnelley gives the following comparison of school efficiency, showing more grant earned and better work done in the mechanically ventilated schools:—

Ventilation.	Percentage of Passes.			Grant Earned.	Volumes CO_2 in 10,000.	Micro-organisms in a Litre of Air.
	Reading.	Writing.	Arithmetic.	s. d.		
3 schools; mechanical	99·6	97·8	92·4	21 8	15·4	8
15 schools; natural .	95·6	90·4	84·2	19 6	22·2	61

He concluded that a school for 1,000 with mechanical ventilation will not cost more than £20 per annum more than with any other system, and that the relative initial cost was as follows:—

Ventilation.	Heating.	First Cost. Heating and Ventilating only.	
		Per Head.	Per 1,000.
		s.	£
Natural ventilation	Open fires . . .	4	200
	Hot pipes small high pressure	8	400
	Hot pipes large low ,,	10	500
Mechanical ventilation with hot air	In new premises . .	17	850
	In old premises altered .	20	1,000

For the conditions under which alone natural means of ventilation may be trusted in a large schoolroom see p. 235.

CHAPTER XXIV.

WATER SUPPLY.

IT is very necessary that the water supply of a school should be pure. Water contaminated by sewage is liable to convey the specific germs of certain diseases, especially enteric or typhoid fever and cholera. Diphtheria has never been shown to be communicated by contaminated water.

In country districts where there is no public service recourse is usually had to wells for the supply of water.

Wells are of two kinds, first, surface, shallow, or superficial wells; and second, deep wells.

Shallow or surface wells are sunk into the subsoil (p. 189), and the water rendered available by them is the *ground water* (p. 191). Deep wells penetrate through the first impervious layer (p. 192), and draw their supply from water lying in the deeper strata. Surface wells are in general use in country districts, on account of the expensive plant necessary to raise water from the lower strata to the surface. Shallow wells being often not more than 15 or 20 feet deep, the water can be brought to the surface by means of a common pump.

The most important pollution of water is contamination with organic matter of excremental origin; this in itself may not be attended by immediately dangerous results; but the micro-organism which produces enteric fever is present in the discharges from patients suffering from that disease, and if this specifically infected matter gains access to a well an outbreak of enteric fever among those drinking the water is certain to occur. Many instances are on record where a well has been subject to pollution from a cesspool for many years without apparent harm resulting to the drinkers; but upon the importation of a case of enteric fever many of the people supplied by the well have been attacked by this disease.

The Natural Methods of Purification.—The soil (see p. 189) is the superficial layer of the earth's crust which supports vegetation. It contains much organic matter together with an enormous number of bacteria. These latter are divided into two main groups: (1) those which grow in the absence of oxygen, and (2) those which grow only in the presence of oxygen. All forms of life, whether animal or vegetable, eventually come under the influence of these bacteria. In an uninhabited country where man has not interfered with nature's methods, the dead leaves, excrement of animals and birds, and other organic matter falling upon the ground are acted upon by the bacteria which grow in the absence of oxygen—the *anaerobic* bacteria. In the process of growth these bacteria act upon the nitrogenous organic matter, and its nitrogen is brought into the simpler form of ammonia (NH_3). This process may be perceived in any new manure heap where the ammoniacal odour is often pronounced; ammonia being very soluble in water is washed by rain into the soil. Here are found organisms known as nitrifying bacteria, whose chief function is to act upon the ammonia converting it into nitrates. These nitrates are used by plants to build up their fresh protoplasm. The cycle indicated above, known as the nitrogen cycle of nature, is the chief means for keeping the nitrogen in combination. Animals unlike plants are unable to elaborate protoplasm from simple inorganic substances, but obtain their nitrogen directly or indirectly from plants in the form of proteids. Given a sufficient layer of soil (*humus*), all effete organic matter is thus naturally converted into harmless and useful nitrates, and there remains no injurious nitrogenous matter to be carried by rainwater into the subsoil. The ground water will under these conditions be uncontaminated, and the water supplied by shallow wells free from danger.

Methods of Pollution.—The bacteria upon whose activity the purification of organic matter depends, have their habitat in the soil. Their number is greatest near the surface. Unoxidised organic matter may therefore be washed into the subsoil and pollution occur (1) where the soil (*humus*) is absent, as sometimes happens over chalk; (2) when there are cracks from the surface to the subsoil, as may be found in clay; (3) when the soil is water-logged, either because liquid refuse is constantly poured upon a small portion of ground (this not infrequently happens in cottages in the country when the slops are flung out of the door), or because the subsoil water is near the level of the ground. In these cases the process of nitrification is inhibited. (4) Where the brick- or stone-work of the well is faulty and allows leakage from the surrounding subsoil, or where the well has no proper coping and water from the surface may actually run into it; and (5) when leaky drains or cesspools introduce organic matter into the subsoil below the level of the nitrifying bacteria.

The means for the prevention of pollution are as follows:—

1. No excremental matter should be placed on ground destitute of humus, or where the subsoil is likely to crack, or where the soil is, or is likely to become, water-logged.

2. Wells must be properly built of brick rendered in cement and lined with cement, and a coping reaching to about two feet above the level of the ground must be provided.

3. Drains and cesspools must be made water-tight.

In towns where a public water supply is provided, the purity of the water may be assumed to be guaranteed by the sanitary authority. There are two systems of supply, **Constant** and **Intermittent.** In the constant supply the mains are connected directly to the taps, and there is always a sufficient head of water to produce delivery of water in the house. In the intermittent system a cistern is inserted between the main and the taps.

The Cistern should be placed above the highest tap in a well-ventilated position and easily accessible. It should be made of glazed porcelain, slate set in cement, or galvanised iron. It should be fitted with a dust-proof cover, and be cleaned out three or four times a year.

Cisterns are provided with a ball-valve so as to keep them constantly full without waste ; and with an overflow pipe of the same size as the inlet pipe in case the ball-valve should get out of gear. This overflow pipe must pass through the wall of the house to discharge into the open air.

The water is distributed from the cistern by means of lead pipes having proper wiped joints at all the junctions, red lead never being employed to form joints between pipes. Every water-closet must have a special flushing cistern independent of the cistern for drinking water, and supplied from the latter if the service of water be intermittent, or from the main if the service be constant. In this way any danger of contamination of the water supply by effluvia from the W.C. is avoided. The overflow pipes from the W.C. cisterns must discharge through the wall of the house into the open air.

Domestic Purification of Water.—In all instances in which the purity of the supply cannot be relied upon special precautions must be taken to render the water safe for drinking. The safest method of treatment is *boiling*, as this effectually kills all disease-producing bacteria. The disadvantages of this method are that heat is necessary, and that boiled water is insipid to the taste.

The alternative method is *filtration*. Great care must be exercised in the supervision of this process: it is not sufficient to purchase a filter and pass all the water through it. Many filters in the market are veritable bacteria traps; the ordinary charcoal filter frequently delivers more bacteria than the original unfiltered water contained. The only efficient filters are those made of unglazed earthenware, the most reliable of which are the Pasteur-Chamberland and the Berkefeld. The former is made of very dense china clay; the latter is made of a diatomaceous earth, and is more porous. The Pasteur-Chamberland

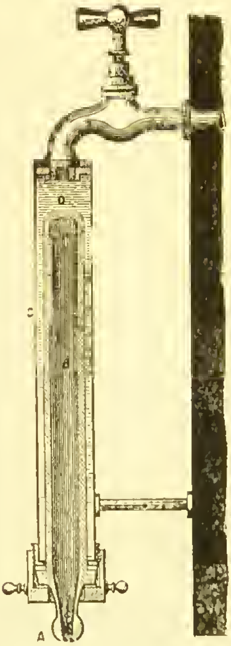


FIG. 35.—Pasteur-Chamberland filter. A, Outlet of filtered water; B, Pasteur tube; C, Metal tube containing unfiltered water; D, Unfiltered water delivered from the tap.

filter is the most satisfactory form for permanent use. In this the "candle" is fastened into a reservoir or chamber so that the glazed open end is watertight. The case is connected with a tap and the water is allowed to filter through. A clean candle will deliver bacteria-free water for about a week; after this time bacteria begin to appear in the filtered water because they have *grown* through the pores of the candle. At intervals of a week, therefore, the candle must be cleaned. This is easily done by removing it and then brushing it in a stream of hot water (subsequently immersing it in boiling water), or by exposing it to the flame of a Bunsen burner.

Common drinking vessels in schools introduce a certain amount of danger: they may be infected by children suffering from such diseases as diphtheria, sore throats, and so on. The cups so infected are capable of passing on the disease to healthy children. It is impracticable to have a separate cup for each child, or to sterilise the cup after each time of using. The usual plan of having a cup chained under the source of water enables the cup to be washed with clean water before drinking from it, and infection is removed by simple washing.

The "Crystal Stream" Drinking Fountain is used in some American schools. This consists essentially of a nozzle surrounded by a ring, on pressure of which water bubbles up from the nozzle. The nozzle being smooth and oval shaped, there is no likelihood of lodgment of saliva, etc.[1]

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[1] Described by Miss Ravenhill, *Journ. San. Inst.*, vol. xxiii., part i., p. 93.

CHAPTER XXV.

DISPOSAL OF WASTE MATTER.

In the preceding chapter mention has been made of the importance of the proper disposal of all waste, including excremental matter. As in the case of many of the problems already discussed, the methods of sewage disposal adopted in towns are not always applicable in the country. In towns, for instance, the school authorities have simply to arrange that all excremental matters are properly discharged into a sewer, and the sanitary authority is responsible for their further disposal. In the country, however, the ultimate disposal of the sewage often devolves upon the school authorities.

Dry Refuse.—The dry refuse of a school includes waste paper and other débris, dust, etc., requiring to be daily removed from the school. Where possible this material should be burnt each day in a furnace; this is almost the only satisfactory method of disposal. In the summer months when there is no fire it is collected into a dustbin. No fixed ashpit should be allowed in towns. The dustbin should be emptied frequently. In towns the removal should take place every day: it is usually carried out weekly or semi-weekly by the sanitary authority. When daily removal is impossible and the refuse is considerable, more than one dustbin must be provided. If a caretaker lives at the school he should receive instructions to burn all vegetable and animal refuse in his kitchen fire.

The dustbin should be made of a non-porous substance such as galvanised iron ; it should be kept constantly covered by a well-fitting lid ; it should not be too large for a man to carry on his shoulders.

In country districts if an ashpit is permitted in lieu of a dustbin it should be built of brick, and both walls and floor lined with cement. It should have a water-tight roof, and should be well ventilated. The opening through which the refuse is placed should be at a convenient height from the floor ; the opening for extraction should be at the floor level, on the side remote from the school ; both openings should be fitted with doors.

Fluid Refuse.—The disposal of fluid refuse necessitates a system of *Drainage.* Separate description is required according as the district has (1) both water service and sewerage ; (2) water service, but no sewerage ; or (3) neither water service nor sewerage.

1. Districts having both Water Service and Sewerage.—There are two kinds of fluid refuse, *viz.*, (*a*) excremental matter, *i.e.*, fæces and urine ; and (*b*) rain water from roofs, lavatory waste water, overflow water (if any) from lavatory and water-closet cisterns, and water used in washing floors, etc.

Excremental matter is carried from the water-closet into the drain when the water-closet is on the ground floor, or into a soil pipe when the water-closet is on an upper storey. The soil pipe is made of lead or iron, passing from the trap of the highest water-closet, through the wall, and running perpendicularly down outside to the drain which commences at the ground level.

The **drain** runs underground, terminating near its junction with the public sewer in a disconnection chamber.

The upper end of the vertical portion of the soil pipe is continued above the eaves of the roof, where it is guarded by wire netting to prevent it from being stopped up by birds' nests, etc.

The soil pipe receives only the contents of all closets and urinals above the ground floor. All other fluid refuse should be led to a trapped gully in the yard, connected directly with the drain. Closets and urinals on the ground floor also discharge directly into the underground drain.

Water-closets for teachers are conveniently placed alongside of the lavatories. A single water-closet, such as would be provided for teachers, must be placed against an outer wall and ventilated by a window, at least 2 square feet in area. The closet should be separated from the schoolroom by an anteroom, or lobby, which also should have a ventilating window, or windows.

The pan of the water-closet should be of glazed porcelain ; it should not be surrounded by woodwork ; it should be so fixed that the surrounding floor-space can be cleansed. Over the porcelain is placed a hinged seat of mahogany, or teak, which can be lifted up when it is required to pour water into the pan. The seat is supported upon an iron frame, fastened into the wall behind the pan.

The shape of the pan is such that the part above the water will not get soiled by ordinary use. The best pans are of the shape known as the " short hopper," or " wash-down " type. The front wall of the pan slopes backwards from above downwards, and the back wall is almost vertical.

The water enters from the back and flows into the hollow rim, which is perforated on its upper lip, so that the whole of the sides of the pan are well washed at each flush. In order to thoroughly flush a basin from 2½ to 3 gallons of water are necessary. This amount is contained in a cistern, placed at least 3 feet above the pan. A syphon cistern is best. In this, the mere pulling or lifting of the handle serves to cause the emptying of the cistern, which is supplied with a ball-valve to prevent waste. The pipe connect-ing the cistern and the pan must be at least 1½ inches in diameter, in order that the water may be discharged with sufficient rapidity to ensure a thorough flush. All the joints of the soil pipe are "wiped," except between lead and earthenware. Here a brass ferule cemented to the earthenware is wiped on to the lead.

Between the pan and the soil pipe is a **trap**; this is a bend at the bottom of the closet pan which holds water and serves to disconnect the air in the soil pipe from the closet. In many cases the trap is formed in one piece with the earthenware of the pan. Fig. 36 illustrates one of the simpler forms of ordinary syphon closets, with an S-trap under it. The depth of the water in the trap which prevents the establishment of aerial communication between the soil pipe and basin is termed its *seal*. It should never be less than 1½ inches. The pipe beyond the trap passes through the wall and joins the soil pipe at as acute an angle as possible, the junction being made by "*wiping*".

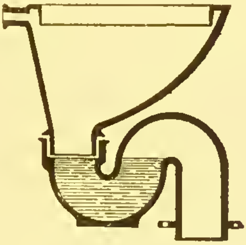


FIG. 36.—S-trap under wash-down water-closet.

When two lead pipes are to be joined together the only satisfactory and indeed the only permissible method is that known as wiping. The two open ends of the pipes are trimmed, one being opened out slightly so as to receive the end of the other, which is scraped away to form a part of a cone. The surfaces are then dried and cleaned by scraping the dull surfaces with a sharp tool. The two pipes are then placed in position so that the end of the one lies inside the end of the other.

Liquid solder (which is a mixture of lead and tin) is then poured over the junction, a small quantity at a time, whilst the plumber holds a pad of moleskin underneath to catch any solder that is spilt. The solder runs in between the ends of the two pipes and fuses them together. During its cooling the solder assumes the consistency of soft putty; whilst in this condition it is moulded by the aid of the pad so that there is about half an inch of metal over the joint. As the cooling proceeds the solder sets and the two pipes become virtually one with a local thickening. If such a joint be cut open it is impossible to see where the original pipes began and ended, so completely are they welded together.

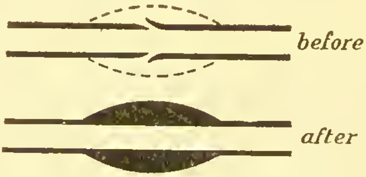


FIG. 37.—Section of "wiped" joint before and after completion.

If two or more closets discharge into different parts of the soil pipe, all the traps except the top one must be ventilated, each ventilating pipe being carried up independently beyond the junction of the highest water-closet with the soil pipe, and then joined into the main ventilating pipe carried above the eaves.

Its use is to prevent the trap which it ventilates from being unsealed by syphonage as water runs down the soil pipe from the closet above; if the trap is not ventilated this may easily happen, and foul air then has access into the building.

Instead of a simple basin like those previously figured a valve-closet may be provided for the teachers. Such a closet is illustrated in the following diagram.

Certain bad forms of closets are still met with, especially in country districts. Such forms are the "long hopper" and the "pan-closet". The former from its shape is very liable to have its sides soiled, and matters are made worse by the fact that commonly it has a "spiral flush" instead of a flushing rim. Cleansing in these closets when flushing occurs is very imperfect (Fig. 39). The pan-closet (Fig. 40) is clearly not permissible, as it presents numerous angles and corners for the retention of excrement.

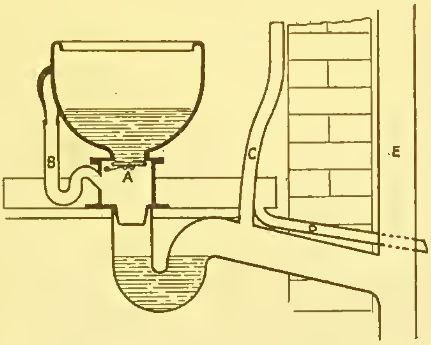


FIG. 38.—Valve-closet. A, valve ; B, overflow pipe showing syphon bend containing water ; C, ventilating pipe joining E the soil pipe at a point above the highest W.C. ; D, overflow from safe-trap, discharging into open air.

The **drain** conveys the contents of the soil pipe to the sewer. It is usually made of glazed socketed earthenware pipes. Successive pipes are joined together by cement so that the joints are absolutely water-tight. They should be laid in straight lines on a hard even bottom, preferably of concrete, in such a manner that the socket end of the pipe points towards the soil pipe and away from the sewer. Whenever a change in the direction of the drain is necessary, an inspection chamber should be provided. A fall of

1 in 30 should be allowed for a 4-inch pipe, and 1 in 40 for a 6-inch pipe. These drain pipes like the soil pipe should be as small as is consistent with the amount of sewage they have to carry. For anything up to ten closets a 4-inch pipe suffices, up to twenty-five closets a 6-inch pipe, and above this a 9-inch pipe.

The drain discharges its contents into a **disconnection chamber.** In this chamber the several pipes usually required in a large school converge, their contents being made to flow down a single pipe to the sewer. The walls of the chamber are lined with glazed bricks rendered in cement, its floor is made of cement with a main channel running through the centre and branch channels to receive branch drains running into the main one as nearly parallel to it as possible. From one wall of the chamber a 4-inch ventilating pipe passes to the open air. This pipe is carried about four feet above the level of the ground and is fitted with a grating to prevent its being blocked up. An iron air-tight lid is placed on the top of the chamber at the ground level. The general character of these arrangements is shown in Fig. 41.

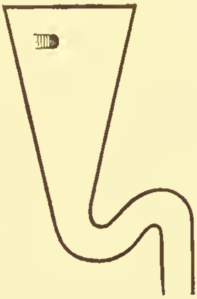


FIG. 39.—Long hopper water-closet.

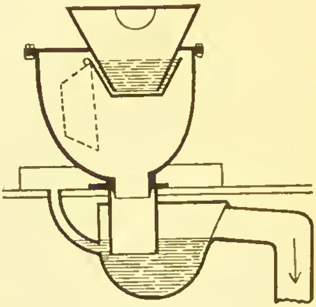


FIG. 40.—Insanitary pan-closet.

The soil pipe, drain and ventilated disconnecting chamber form one unbroken system through which air can pass uninterruptedly, there being access and exit for gases at each end of the system. Consequently when the soil pipe or drain becomes accidentally blocked there is no risk of forcing the water seals or traps and allowing foul gases to enter the house.

The main channel of the disconnecting chamber runs directly into a pipe communicating with the sewer. Immediately on leaving the chamber the pipe is trapped to prevent the access of sewer gases to the chamber and thence to the whole drainage system.

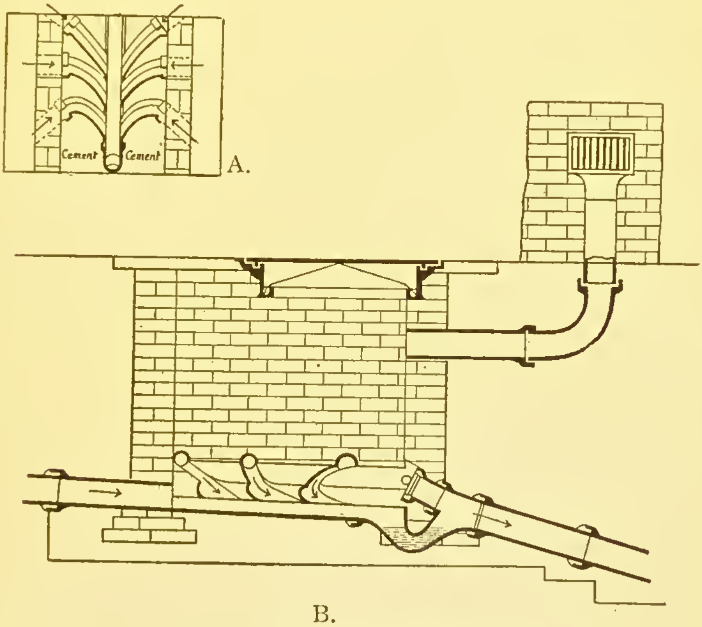


Fig. 41.—Disconnecting chamber.
A, Plan. B, Section.

We have thus traced the excremental matter from the closet to the sewer, where in towns it can be left to be dealt with by the sanitary authority. Country schools will need separate consideration (p. 278).

Closet and Urinal Accommodation for Scholars.—In naturally ventilated buildings the closets and urinals should be separate from the school buildings, but when artificial ventilation by fans is adopted the closets may be placed in the basement, provided they have a distinct system of ventilation of their own.

The minimum accommodation is that given in the Day School Code (p. 302), namely, one closet for every fifteen girls, and one closet for every twenty-five boys: there should in addition be one urinal for every fifteen boys.

The buildings should be placed at least 20 feet from the main school. If inconveniently situated or at too great a distance, the scholars are apt to avoid using them when they should do so. They should be made light, airy, and easy to clean.

The closet should be between 2½ feet and 3 feet wide and about 4 feet deep. The walls and floors should be made of cement with all the corners rounded off. The floors should slope towards a gully so that the water may easily drain away after washing. The woodwork of the door should commence about 1 foot above the floor and terminate about 1 foot from the top.

The basin of each water-closet should be without wooden encasement to ensure efficient cleansing. A valveless basin must be used, and a simple S or anti-D trap connected directly to it. Infant school children cannot reasonably be expected to flush the basin after use: for them arrangements for securing automatic flushings are desirable. This can be effected by an arrangement in which rising from the seat brings the flush into operation, or by an automatic time flush acting at regular intervals. The first method is open to the objection that wilful misuse may occur. The objection to the second method is that inconvenience may result from the flushing of the basin while in use.

The seats should be made of hard wood and not so high as usually arranged. It is far better to have the seats too low than too high.

Trough-closets.—Instead of single basins for each closet, troughs are often used, there being several seats above the common trough, which is automatically flushed at regular intervals. These closets are always unsatisfactory. When they are flushed there is a considerable nuisance owing to the disturbance of the accumulated excrement lying in the trough. In the intervals of flushing the scholar using the closet is exposed to the effluvia of the excrement of other children which may be incompletely covered with water.

Urinals.—The sides and backs of urinals should be composed of slate or porcelain, or other impervious smooth material without angular joints ; the floor should consist of smooth cement made to slope to a wide groove with a fall towards one end, terminating in a trapped gully which communicates with the drain. There should be no projecting ledges in the urinal ; every urinal must be well flushed with water and daily scrubbed with a broom.

2. Districts having a Plentiful Water Supply but no Sewerage.—Internal arrangements will be identical with those just described, up to the point at which sewage leaves the disconnection chamber. The rain water must be dealt with separately. From the disconnection chamber the sewage runs into a water-tight underground cesspool, or what is almost identical, a septic tank, through a glazed earthenware pipe having properly cemented joints laid upon a proper bed (p. 273). This septic tank should be at least 50 feet from the school and 80 feet from any well. It must be situated below the level of the disconnection chamber so that the sewage may easily run into it.

An overflow to the cesspool is arranged, and arrangements made for disposing of the effluent sewage. This is best disposed of by running it on to the land, where it is made harmless and useful. In order to do this a field is drained with agricultural tiles, that is, porous tiles without sockets, which are laid so that several drains with a downward slope radiate from a certain spot. At the spot from which the drains radiate is placed a large flushing tank of about forty gallons capacity which automatically discharges the whole of its contents when it becomes full. The discharge pipe from the cesspool communicates with the flushing tank by means of a glazed earthenware drain. The flushing tank is inserted to insure that a comparatively large quantity of fluid will be discharged down the porous drains at once, distributing the sewage over the ground and preventing it from becoming waterlogged as would happen if there were a constant trickling of sewage into the drain.

3. Districts having no Water Service.—In many country districts the following insanitary practice is still pursued: A pit is dug in the ground and may or may not be lined with cement. Over the pit a privy is built containing a closet seat with a lid, the urine and fæces falling directly into the pit. If lined with cement the contents of the pit putrefy, and the malodorous gases rise into the privy. The pit gradually fills and its emptying is a disgusting process. If the pit is not cemented the fluid matter soaks, unoxidised, and, therefore, with all its potentiality for evil, into the soil, and possibly into the nearest source of water; the more solid matters being left exposed to the air, putrefy more slowly and with less odour, but the offensive process of emptying becomes eventually necessary.

Dry Earth Method.—The treatment of excreta with dry earth is nature's method, the natural process of nitrification by the soil converting the effete organic matter into substances useful for plant life. The great objection to this method, except in the country, is the difficulty of obtaining and storing dry mould, and subsequently removing the product. When the process is properly carried out the excrement disappears, and the mould may be used over and over again if kept dry. There is always the danger, however, of mismanagement, and for towns the earth-closet is inadmissible. In the country, where mould is plentiful and its disposal easy, this is the best and most economical method.

The closet must have smooth walls, a water-tight roof and cement floor. It must be furnished with a window and door, with proper arrangements for ventilation. The seat is fixed to the walls and underneath it is a pan of galvanised iron with a capacity of 2 or 3 cubic feet furnished with handles. In the wall behind the pan is an opening, fitted with an air-tight door, for the removal of the pan when full.

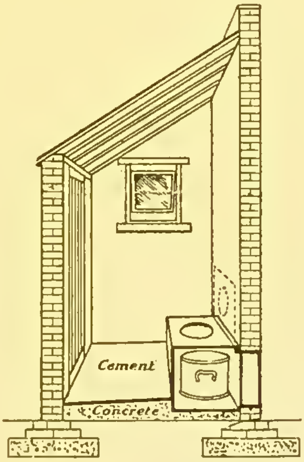


FIG. 42.—Earth Closet.

Method of Using.—Many dry earth-closets cause a nuisance, because they are not used properly. In the first place, the soil should be dried in the sun or in the air under a roof. It should not be heated in a kiln as the nitrifying organisms are thus destroyed. Secondly, a sufficiency of earth should be used on each occasion. When properly used there is no nuisance. If such a closet emits an odour a considerable amount of fluid is invariably found in the pan. As a working rule it may be said that sufficient earth must always be added to the pan to keep the contents dry. If such a closet could be used only for solid excreta but little mould would be necessary, but as this is impossible care must be taken to add sufficient soil, not only to cover the solid matter but to absorb all the urine. When a sufficient amount of earth is added there is no odour.

The pans being small require frequent emptying, but this process is quite inoffensive. A trench about a foot deep is dug in the ground and the contents are emptied into it and covered over with the soil removed from the trench.

Scholars cannot be expected to see that the soil is added, and suitable arrangements must be made by the head teacher. If soil were placed in the pans daily this would probably suffice to keep the pans sweet, but a better method is to have an arrangement in which the act of rising from the seat opens a valve and causes dry earth from the box at the back of the seat to fall upon the excreta. It is necessary to see that a constant supply of dry earth is kept in the box. Instead of earth a mixture of dry earth and sifted ashes may be used.

CHAPTER XXVI.

SCHOOL FURNITURE.

One of the greatest difficulties with which the managers of a school have to contend is the provision of suitable furniture for the scholars. During a small portion of the school day the scholars may be standing or drilling, but usually are sitting at their desks. If all children of the same age were also of the same size, the selection of furniture would be easy; even if the size of the child and his standard of intelligence went together, the difficulties would be slight; but under usual conditions, in which no proportion obtains between physical development, mental development, and age, the difficulty can only be overcome by having a single desk for each scholar.

Before the necessity for suitable desks was realised, children of varying ages and sizes were often seen seated at a long desk holding perhaps six or eight: with the result that they were forced to assume attitudes which were both ridiculous and fraught with calamitous consequences.

A child engaged in reading should be erect. In this posture the reading-book should be at the normal distance for reading, *viz.*, 10 inches from the eye: any other position is likely to cause eye-strain, and favours curvature of the spine. The choice of a suitable desk for each child is most important, as the injury done to eye or spine in extreme cases is permanent. An adult may with less danger sit for considerable periods at an unsuitable seat. In his case the development of the body is complete, and therefore malformations, even if they occur, are but slight. In the child the wrong postures become habitual during the process of development, when the tissues will adapt themselves to circumstances, and what was begun as a functional disfigurement becomes gradually fixed as a structural and permanent defect.

When a child is lying down the various muscles are at rest, but a child in the sitting posture is far from resting. Although in sitting the amount of muscular work compared with that necessitated in standing is small, yet the muscles engaged in keeping the head erect, and to a less extent the muscles of the back, are in a state of constant contraction, and especially so when the child is leaning slightly forward as in the act of writing. If in the sitting posture the body is upright and symmetrical, there will be no undue contraction of any particular sets of muscles; consequently there will be no tendency for the body to be drawn out of the symmetrical position. If, however, the child sits in an asymmetrical position, one set of muscles will be acting more powerfully than another, and the consequent pulling of the muscles on the bones will in time induce structural changes corresponding to the asymmetrical position adopted by the child.

No form of desk or seat will obviate the evils of long continuance in any one position, however perfectly the desk may fit the scholar. The sitting posture, even when erect, does not allow the complete expansion of the lungs. This is only obtained in the standing position; and it is therefore desirable to give the child a few minutes' interval in order to expand his lungs when he has been sitting at a perfect desk for twenty minutes or half an hour.

The Seat and Desk.—Although authorities are not in complete accord as to the best form of seat and desk, they all agree that combined desks, which seat six or eight children, are the worst possible; and that the dual desk is the greatest concession in this direction which is permissible. Even dual desks, however, necessitate bad postures in children and imply too close personal contact. The bad postures are adopted to avoid copying, and the close contact greatly favours the spread of the finer infections such as diphtheria and the coarser such as ringworm and lousiness. With single desks the space required to seat a number of children is necessarily greater than when two or more are seated at the same desk, and this might seem to necessitate louder speaking on the part of the teacher. The audibility of a teacher's voice in even a large classroom depends, however, more upon clear enunciation than upon mere loudness of voice.

The teacher above all others should speak very clearly, if only as an example to his scholars. Single desks may, if attention is not given to individual cases, imply the seating of short-sighted scholars at desks too remote from the blackboard. This is easily obviated by giving such scholars front seats and placing others with normal vision farther back. The single desk in practice tends to keep down the size of the class, and thus diminishes the evils of school aggregation, and increases the efficiency of teaching (page 70).

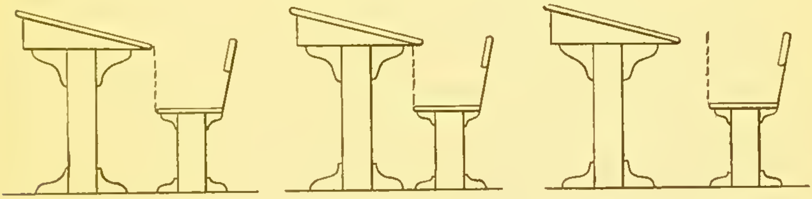
The single desk having been adopted as the best form, several points must be remembered (*a*) in selecting a particular form of desk, and (*b*) in fitting a desk to a particular child. (*a*) **As to form of desk.** —It is necessary to remember that at the desk the child may sit listening to the teacher and watching the blackboard, or he may be reading from a book, or he may be writing. Some form of desk must therefore be adopted which will enable him to do each of these with the greatest ease and least discomfort. A desk might conceivably be designed which would be perfect for writing but very inadequate for reading, or suitable for reading and writing and unsuitable for sitting listening to the teacher. The desideratum is a desk which combines the greatest advantages in each position with the fewest disadvantages for the other positions.

The seat and desk should be so arranged that the child's feet rest on the floor in every position of his body; he should be able to lean back, preferably against a hip rest (see p. 96); the top of the desk should be in such a position that he can easily read the book laid upon it, and with such a slope that he is able to write without bending his body to a considerable extent.

The Seat.—The difficulty of finding seats of fixed height to fit the scholar being so great, it is advisable to have adjustable seats. The same remark applies to desks. By an adjustable seat is not meant one which the scholar himself can alter at will, but one which by or under the supervision of the master can be altered periodically: the range of movement need not be great, and the method of fixing must be simple. The seat itself must be wide enough to support the body with comfort; it should not be flat, but slightly concave, this concavity not exceeding about three-eighths of an inch, and the trough of the concavity should be placed where the seat-bones rest upon the seat. This serves two purposes—it enables the scholar to assume the upright position without the body sliding forward on the seat, and it is most comfortable during all the positions assumed by the scholar. At the back of the seat there should be a vertical rest extending to a height above it corresponding with a point of the child's back, when seated on the chair, just below the level of the shoulder-blades. This rest does not extend the full width of the seat, but occupies about the central four inches. When the scholar is seated, the lower leg or shin should be vertical, with the foot resting entirely upon the floor, and the upper leg or thigh horizontal, the adjustment being varied to enable this position to be adopted.

The Desk.—It is important in the first instance that the arrangement of the desk should not interfere with the position of the legs previously mentioned. Hence if the desk is to be used as a receptacle for books, etc., this receptacle must be shallow, inasmuch as the lid of the desk, as will be shortly seen, must be sufficiently low to enable the scholar to write comfortably.

There are three positions of the desk in relation to the seat: (*a*) The back of the desk immediately overhangs the front of the seat; (*b*) the desk is partially over the front edge of the seat; or (*c*) there is an interval between the desk and the front of the seat. In the third position the distance of the scholar's eye from the desk is too great, and he is obliged to lean forward in reading and writing.



(*a*) (*b*) (*c*)

FIG. 43.—Showing three relative positions of seat and desk.

It is now generally agreed that the second position in which there is a slight "overhang" is the most advantageous; the distance between the eye and the desk is then about 12 inches, and a scholar with normal vision is able to read and write while sitting very nearly erect.

The top of the desk must not be horizontal, but should incline with an angle of 15° to the horizontal.

This inclination has been found to be the best in practice, and has been adopted by the Board of Education (see p. 303); it is really the mean between the best for reading and the best for writing.

The desk, like the seat, should be adjustable, so that the scholar's eyes, when he is in the upright position, are about 12 inches from the desk; this has been found to be the best distance for easy vision. It is the duty of the teacher periodically to adjust the desks when he adjusts the seats; and with seat and desk thus adjusted the likelihood of such an attitude being assumed as would hinder the proper physical development of the child is reduced to a minimum (see also page 113).

In the Bradford schools Dr. Kerr has recommended seats and desks of the following dimensions:—

	Infants.		Standards.		
Inches. Sizes .	Babies.	Infants.	A. I. and II.	B. III. and IV.	C. V. and VI.
	Ins.	Ins.	Ins.	Ins.	Ins.
Group height of children . .	38	42	45	50	55
Height of desk edge above seats . .	6	7½	8	8½	9½
Height of seat from floor . . .	9	11	12½	14	16
Size of seats . .	11 × 8 × 1½		11 × 9 × 1½		11 × 10 × 1½
,, ,, back rests .	8 × 5 × 1¼		8 × 5½ × 1½		

In any district the sizes required would depend upon the physical characteristics of the children. Probably the above sizes are a little below the average requirements for the entire country. Dr. Kerr also quotes the following dimensions of dual desks of the Bennett pattern as being made for the London School Board:—

Description of desk .	No. 1.	No. 2.	No. 3.	Kindergarten.
	Ins.	Ins.	Ins.	Ins.
Height of seat	17	15½	13½	11½
,, ,, desk edge . . .	29½	27½	23½	20
Seat, desk—vertical *difference* .	12½	12	10	8½
,, ,, —horizontal *distance*	A positive distance under 2 inches, as fitted by the makers in the Leeds schools.			

Note.—Difference is the difference between the height of the seat and the edge of the desk; *distance* is the distance *positive* or *negative* between the front edge of the seat and a perpendicular line dropped from the edge of the desk. Dual desks are unfortunately not yet condemned by the Code as they ought to be. Each child should have a separate desk and seat.

The Teacher's Platform.—At one end of the room there should be a slightly raised platform for the teacher. It should be placed against a wall which has no windows, the chief light it receives coming in through windows on the scholars' left. In height it need not be more than one foot or a foot and a half above the ground: this will enable the children sitting at the back of the class to see the teacher's face without assuming strained attitudes in the attempt.

Blackboards.—The chief essentials of blackboards are that they shall be black and yet have a matt, *i.e.*, unglazed surface. If the board is properly placed in relation to windows there is no difficulty in avoiding the reflection of light from its surface which would render the writing on it illegible. Slate is easier to cleanse than a blackboard; but it possesses the disadvantage of being rarely black.

Whether a blackboard or slate is used, white chalk should always be used for ordinary work, as the contrast between the board or slate and white chalk is much greater than between them and coloured chalks (see also p. 93).

Slates.—The only advantage of slates for scholars is that they are economical. There is, we think, an over-balancing disadvantage inasmuch as their interchangeability constitutes a distinct danger. All work in writing, except in infant schools (see p. 89), should be done on paper with pencil or ink, with pencil by the younger, with ink by the older pupils. The contrast between the black lead or ink and white paper is much better than that between the grey of the slate and the lighter grey of the slate pencil.

Books.—In recent years a great change for the better has taken place in the books used by school children ; each class has its own particular books, and the size and print are more appropriate to the age of the scholar than was formerly the case. The printing is discussed in Chapter VII. (p. 94) ; here it may be mentioned that no school book should be printed upon glazed paper : white matt paper should be used and the print should be of the deepest black ; the greater the contrast between paper and ink, the easier is the child's task and the less the chance of eye-strain.

Exercise books for writing in ink necessarily have a slight glaze, but excellent paper is now made with a glaze so slight as to be scarcely noticeable.

Maps and illustrations for educational purposes should be chosen which do not strain the eyes, and maps particularly should show what the teacher wishes them to show with great distinctness ; they should not be overcrowded with small print.

CHAPTER XXVII.

CLEANSING AND DISINFECTION OF THE SCHOOL.

It is quite as important that the school buildings should be kept clean as that they should be specially adapted for scholastic work. Dust we have seen (p. 214) is by no means harmless. It may contain micro-organisms which have the power of imparting disease to those inhaling them. Certain of the infectious diseases may be transmitted from one child to another by such articles as slates, books, etc. (p. 138), these having become infected from the mouths and throats of children suffering from unrecognised attacks of these diseases. It is therefore very necessary to see that the danger from these sources shall be, so far as is possible, eliminated by the strictest attention to cleanliness. When a school, or a department of a school, has been closed with a view to prevent the spread of some infectious disease, a special form of cleansing is necessary. In other words, the school or department must be disinfected.

Dust which has been lying in a school for some time is much fouler than the daily accumulation of dust. It is this old dust which causes the "stuffy" smell. Hence the importance of not having spaces under platforms, etc., in which undisturbed dust can collect. Maps and pictures, unless frequently taken down and cleansed, harbour dirt and devitalise the air of the school.

1. Ordinary Cleansing.—The cleansing of a school can only be rendered effective if both school managers and teachers fully appreciate its importance and are prepared to devote time to its supervision, and spend sufficient money in securing the requisite number of workers. This cleansing comes under three heads—daily and weekly cleansing, and special cleansing during vacations.

Daily Cleansing.—Immediately afternoon school is closed, all windows and doors should be opened widely to thoroughly ventilate the school. A supply of wet sawdust must be kept in readiness, and all the floors sprinkled with this in order to keep down the dust when they are being swept. The mixed sawdust and dust collected by sweeping should be destroyed by burning. The sawdust employed for sprinkling the floor should have been soaked in water over night, in order that it may effectively imprison the dust, a fresh supply of sawdust being left to soak for the next day's sweeping.

Furniture.—After the floor has been thoroughly swept, the desks, blackboards, window-sills, cupboards, etc., should be thoroughly dusted with a damp cloth. Any modicum of dust which re-settles during the night on the furniture should be removed by wiping it over with a damp cloth before morning school begins.

It may be noted here that school-keepers, to prevent dust entering the school, commonly close windows immediately after sweeping, so that no efficient ventilation is going on out of school hours. Strict injunctions to keep windows wide-open when the school is empty should be given.

Weekly Cleansing.—In most schools the school week is from Monday to Friday, or from Monday to Saturday with half-day holidays on Wednesday and Saturday. When there is a whole day holiday on Saturday there is ample time for the school to have a thorough weekly cleansing. In addition to careful brushing and dusting, desks, blackboards, hat-rails, and the woodwork generally should be washed with soap and water and the windows should be cleaned. It may seem rather unnecessary as well as expensive to clean the windows every week; but with dirty windows there is considerable loss of light, and windows should therefore be cleansed at such frequent intervals as will ensure their always looking bright and clean. At the least the inner surface of the windows may with advantage be cleansed weekly, even if the outside surface is cleansed only at longer intervals. Quite recently it has been suggested that the floors of schools should be painted with a coating of what is known as a dustless floor oil; it is claimed that the oil, which soaks to some extent into the floor, prevents the dust from being dispersed in the air when the scholars or the teachers are walking about the room.

Vacation Cleansing.—During the vacation at the end of each term the whole of the school buildings and school furniture should be thoroughly cleansed. The walls should be washed down. If they are painted (see p. 209) the washing is easily done; but if, as is unfortunately still the case in many of our English schools, the walls are covered with distemper, this should be washed off and a fresh coating of distemper substituted. It will be seen that the maintenance of walls in proper condition is considerably more costly when distempered than when painted, so that although the initial outlay is greater, painted walls are ultimately much more economical. The floors should be thoroughly scrubbed with soft soap and water. All the window frames and ledges, external surfaces of the cupboards, blackboards, etc., should be treated in a similar manner. The windows should of course be cleaned on both their external and internal surfaces.

The school desks, seats, etc., which are generally varnished and not painted, will suffer in appearance by being washed in the manner above described, and perhaps the best method for cleansing them is to rub them all over well with a cloth saturated in the paraffin oil of commerce. The cleansing of desks is much neglected.

If slates are used they should be washed with soap and water like the floors and windows. The books should be taken out of the cupboards, and the dust removed from the tops of the leaves, etc., by dusting with a damp cloth and subsequently hitting two books together in the yard; after being thus beaten they should be again well dusted and replaced in the cupboards after the latter have been washed and scrubbed with soap and water. Lead pencils and slate pencils, if the latter are unfortunately used, should be steeped in water for twenty-four hours, under a tap, the water being kept running slightly during this time.

Special Cleansing. — By "special cleansing" is meant disinfection. After epidemics of infectious diseases, such as diphtheria and scarlet fever, special precautions require to be taken to prevent the recrudescence of the disease after the reassembly of the scholars. The plan of fumigating the school with the fumes of burning sulphur cannot be recommended, since it has been shown that this procedure does not destroy certain easily destructible bacteria. The real good is done by the cleansing which follows the fumigation, the latter constituting really a kind of fetish. The best plan of disinfecting the ceilings, walls and floors, as well as the desks and furniture, is to spray or wash them with a solution of formalin (*i.e.*, a 40 per cent. solution of formic aldehyde) or carbolic acid. Formalin is used in a strength of about 1 in 40; carbolic acid in a strength of 3 or 4 per cent. After the use of a disinfectant spray or wash, the infected school or classroom must be cleansed in the same way as has been described for the vacation cleansing (p. 291). Books, however, require exceptional treatment. The books used in schools may be responsible for considerable spread of infection. Since books can neither be boiled nor soaked in disinfecting fluid without damage, special means have to be adopted for their disinfection. One method is to place the books up-ended and as widely opened as possible in a box or chamber in which the vapour of formalin is produced by evaporation of paraform over a lamp. This method does not damage the books.

It is doubtful if this method ensures absolute destruction of infection adhering to the leaves of a book. If there is strong reason to suspect that books are capable of conveying infection, one of two plans must be adopted : (1) All the infected books should be destroyed. This is the best plan if their value does not involve serious sacrifice. (2) The books should be subjected to disinfection by steam under pressure in a public disinfecting station. The covers of the books thus treated are somewhat damaged : but absolute destruction of germs of infection is secured.

APPENDIX I.

(*From the Code of the Board of Education for* 1900-1901.)

SCHEDULE VII.

☞ Article 85 (*a*) of the Code provides as follows: "All new school premises and enlargements must conform generally to the rules contained in Schedule VII., and the plans must be approved by the Department before such new premises and enlargements are passed under this Article".

Rules to be Observed in Planning and Fitting up Public Elementary Schools.

School planning is the science of thoroughly adapting every part of a building, even the minutest detail, to the work of school teaching. Convenience of plan, suitable lighting, proper subdivision into classes, and thorough ventilation, with *warmth but* without *draughts, are its leading essentials. Attention to small points is of extreme importance. Sanitary laws are here as vital as in a hospital. The school architect is recommended first to perfect his plan. His own skill should then enable him to clothe it with form, proportion, character and colour.*

These Building Rules are intended to assist School Managers, School Boards and their Architects to produce the most compact, convenient and economical plans of School Buildings.

The annual cost of maintenance should be kept in view as much as the capital expense.

It is desirable that, before instructing an architect, the teaching staff of a school should be well considered, so that the number of rooms and the accommodation of each may be approximately settled before the expense of building is incurred.

REQUIREMENTS.

School Boards and School Promoters are requested to note that the Board of Education require the following Plans, and that inattention to such requirement causes unnecessary correspondence and delay:—

I.—A Block Plan of the Site, drawn in ink to a scale of 20 feet to an inch. This plan must indicate—

(*a*) The position of the school buildings.
(*b*) Out-buildings.
(*c*) Playground.
(*d*) Drains (collateral and main), with their fall and depth below ground.
(*e*) Entrances.
(*f*) Boundary walls, or fences, and their nature.
(*g*) Roads.
(*h*) The points of the compass.
(*i*) The levels of the ground at the principal points.

(*N.B.*—For approval of site alone, the plan should show (*g*), (*h*) and (*i*).)

II.—A Plan of each Floor of the Schoolrooms (and Teacher's or Caretaker's Residence, if any), drawn in ink to a scale of 8 feet to an inch. The internal fittings of the rooms (*fireplaces*, *groups of desks*, *benches*, *etc.*) must be accurately shown. The plan should also state whether the rooms are intended for boys, girls, or infants. In cases of enlargement, a plan showing the buildings as they exist is needed.

III.—Sections and at least four Elevations, also drawn in ink to a scale of 8 feet to an inch. The ceiling, the positions of window-heads in relation thereto, and the mode of ventilation must be shown.

N.B.—(a) *Pencil drawings cannot be received, but coloured tracings in ink on tracing cloth may be submitted while plans are in the preliminary stage of pencil, so that suggested alterations can be adopted without difficulty or expense.*
(b) *Diagrams are of no value and cannot be accepted.*
(c) *In the case of enlargements or alterations, the whole site and the existing building should be as accurately shown in every respect as the proposed changes.*
(d) *All plans should be dated, the scales drawn on, and dimensions figured.*

IV.—A Detailed Specification separated under the several branches of the Building Trade.

V.—A Section of the Desk proposed to be used, drawn to a scale of 1½ inches to a foot. *N.B.*—The edge of the desk when used for writing should be vertically over the front edge of the seat.

BUILDING RULES.

1. Planning and Accommodation.

1. In planning a school, the first thing is to seat the children in the best manner for being taught. The accommodation of each room depends not merely on its area, but also on its shape (especially in relation to the kind of desk proposed), the positions of the doors and fireplaces, and its proper lighting. The second point is to group the rooms together in a compact and convenient manner.

2. and 3. Schoolrooms.

2. Every school must have a schoolroom as hereunder or a Central Hall as under Rule 8. The proper width for a schoolroom is from 18 to 22 feet. In a room 18 feet wide groups of long desks,[1] three deep, should be used; where four rows are used the width should be 21 feet 6 inches, and if the width is 22 feet, dual desks five rows deep, are most suitable. (For Classrooms, see Rule 7.)

(*a*) Accommodation in schoolrooms for elder children is calculated by the number of children seated at desks and benches, subject to a minimum of 10 square feet per child being provided. For the mode of calculating accommodation in classrooms see Rule 7, in infant schools see Rule 16 (*f*).

(*b*) Double bank schools (now almost obsolete) require rooms 32 feet wide, walls left clear for three rows of desks, and ample lighting from windows on both sides extending to ceiling.

(*c*) Wasted space cannot be considered.

3. The doors and fireplaces should be arranged so as to allow the whole of one side of any school or classroom to be left free for the groups of benches and desks.

(*a*) No schoolroom lighted from one side only can be approved. The gable ends should be fully utilised for windows. (See also Rules 9 and 9 (*b*).)

4. Walls, Floors and Roofs.

4. The walls of every room used for teaching, *if ceiled at the level of the wall-plate*, must be at least 12 feet high from the level of the floor to the ceiling; and, if the area contain more than 360 superficial square feet, 13 feet, and, if more than 600, then 14 feet.

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[1] On this bad advice, see p. 283.

(*a*) The walls of every room used for teaching, *if ceiled to the rafters and collar beam*, must be at least 11 feet high from the floor to the wall-plate, and at least 14 feet to the ceiling across the collar beam.

(*b*) Great care should be taken to render the roofs impervious to cold and heat.

(*c*) Roofs open to the apex are not approved. They can only be permitted where the roofs are specially impervious to heat and cold, and where apex-ventilation is provided. Iron tie-rods are least unsightly when paced horizontally.

(*d*) The whole of the external walls of the school and residence must be solid. *If of brick*, the thickness must be at least one brick and a half; and *if of stone*, at least 20 inches.

(*e*) All walls, not excepting fence walls, should have a damp-proof course just above the ground line.

(*f*) The vegetable soil within the area of the building should be removed, the whole space covered by a layer of concrete not less than 6 inches thick, and air bricks inserted in *opposite* walls to ensure a through current of air under floors for ventilation to joists.

(*g*) Timber should be protected from mortar and cement by asphalt or tar.

5. ENTRANCES.

5. Entrances should be separate for each department. In large schools more than one entrance to each department is desirable. (See also Rule 10.) The principal entrances should never be through the cloakroom. Entrance doors and the doors of main rooms should open outwards as well as inwards. A porch should be external to the schoolroom. An external door having outside steps requires a landing between the door and the steps.

6. CLOAKROOMS AND LAVATORIES.

6. Cloakrooms should not be passages and should be external to the schoolrooms and classrooms, with gangways at least 4 feet wide between the hanging-rails, and amply lighted from *the end*. They should not be placed against a gable wall. (See Rule 3 (*a*).) The hanging-rail should be arranged so that the children can enter and leave the cloakroom without confusion or crowding. Hat-pegs should be 12 inches apart, numbered, and of two tiers. The lineal hanging space necessary to provide a separate peg for each child is thus 6 inches.

Thorough ventilation is essential, so that smells are not carried into the school.

Lavatory basins are needed. (See Rule 13 (*h*).) Girls' schools require a larger number than boys' or infants'.

A lock-up slop sink, water tap and cupboard are desirable for the caretaker.

7. CLASSROOMS.

7. Classrooms are calculated at 10 square feet if not providing accommodation for more than 60 children. Six rows of dual desks or five rows of long-length desks are permissible in such classrooms. Rule 2 applies to all rooms providing accommodation for more than 60, or being more than 24 feet 8 inches deep from the window wall.

In all classrooms the children's desks should be so arranged that the teacher's desk shall be not more than 20 feet from the centre of the back row, and that that row shall not subtend an angle greater than 60° at the teacher's desk.

(*a*) The minimum size of classroom is 18 feet by 15 feet. If desks are placed longitudinally the width should not be less than 16 feet. This latter width is also allowed in schoolrooms of very small size.

(*b*) The classrooms should never be passage rooms from one part of the building to another nor from the schoolrooms to the playground or yard, and should be on the same level as the schoolroom. Each should be easily cleared without disturbance to any other room. Doors should open both ways.

(*c*) The number of classrooms should be sufficient for the size and circumstances of the school.

(*d*) The excessive use of movable partitions should be avoided.

8. HALLS.

8. Large schools are sometimes planned with a Central Hall, from which the classrooms are entered. The Hall must be fully lighted, warmed and ventilated, and must contain a floor-space of not less than 1,200 square feet. Halls of excessive size are not approved.

It is not desirable, as a rule, to provide for the teaching of classes in a Central Hall, except in the case of a mixed school, where the presence of a teacher in the Hall, teaching a class, is beneficial in keeping order among the children passing through.

In infant schools, a class in the Hall is especially to be avoided, because the exercises and marching of the infants prevent it from being efficiently taught.

In boys' and girls' schools, one class (or under special circumstances two classes) may sometimes be allowed in the Central Hall, if the Hall is suitably planned for the purpose.

9. WINDOWS.

9. Every part and corner of a school should be fully lighted. The light should, as far as possible, *and especially in classrooms*, be admitted from the left side of the scholars. [This rule will be found greatly to influence the planning. (See Rules 3 (*a*), 9 (*b*) and 11 (*a*).)] All other windows in classrooms should be regarded as supplementary, or for summer ventilation. Where left light is impossible, right light is next best. Windows full in the eyes of teachers or scholars are not approved. In rooms 14 feet high any space beyond 24 feet from the window wall is insufficiently lighted.

(*a*) Windows should never be provided for the sake merely of external effect. All kinds of glazing which diminish the light and are troublesome to keep clean and in repair should be avoided. A large portion of each window should be made to open for ventilation and for cleaning.

(*b*) The sills of the main lighting windows should be placed about 4 feet above the floor. And the tops of some should reach nearly to the ceiling, with a portion made to swing. The ordinary rules respecting hospitals should here be remembered. *Large spaces between the window heads and the ceiling are productive of foul rooms.*

(*c*) Skylights are objectionable and should never be resorted to where windows are possible. Plans needlessly involving their use cannot be approved, cxcept in the case of central halls having ridge, or apex, ventilation.

10. STAIRCASES.

10. A staircase should be fireproof and external to the schoolroom. No triangular steps or "winders" should be used. Each step should be about 13 inches broad and not more than 5½ to 6 inches high. The flights should be short, and the landings unbroken by steps. The number of staircases should be sufficient, not only for daily use, but also for rapid exit in case of fire or panic.

11. VENTILATION.

11. Apart from open windows and doors, there should be provision for copious inlet of fresh air; also for outlet of foul air at the highest point of the room; the best way of providing the latter is to build to cach room a separate air chimney

carried up in the same stack with smoke flues. An outlet should have motive power by heat or exhaust, otherwise it will frequently act as a cold inlet. The principal point in all ventilation is to prevent stagnant air. Particular expedients are only subsidiary to this main direction. Inlets are best placed in corners of rooms farthest from doors and fireplaces, and should be arranged to discharge upwards into the rooms. Gratings in floors should never be provided. Inlets should provide a minimum of 2½ square inches per child, and outlets a minimum of 2 inches. All inlets and outlets should be in communication with the external air. Rooms should, in addition, be flushed with fresh air from windows about every two hours.

A sunny aspect is especially valuable for children, and important in its effects on ventilation and health.

(*a*) Although lighting from the left hand is considered so important, ventilation in summer demands also the provision of a small swing window as far from the lighting as possible, and near the ceiling.

12. WARMING.

12. The warming should be moderate and evenly distributed so as to maintain a temperature of from 56° to 60°. When a corridor or lobby is warmed, the rooms are more easily dealt with, and are less liable to cold draughts. Where schools are wholly warmed by hot water, the principle of direct radiation is recommended. In such cases open grates in addition are useful for extra warming occasionally, and their flues for ventilation always.

(*a*) A common stove, with a pipe through the wall or roof, can under no circumstances be allowed. Stoves are only approved, when—

- (i) provided with proper chimneys (as in the case of open fires);
- (ii) of such a pattern that they cannot become red-hot, or otherwise contaminate the air;
- (iii) supplied with fresh air direct from the outside, by a flue of not less than 72 inches superficial, and
- (iv) not of such a size or shape as to interfere with the floor-space necessary for teaching purposes.

(*b*) A thermometer should always be kept hung up in a school.

13. SANITARY ARRANGEMENTS.

13. Water-closets within the main school building are not desirable, and are only required for women teachers. All

others should be at a short distance and completely disconnected from the school. Privies should be fully 20 feet distant.

(*a*) The doors, staircases and passages leading from the schoolroom to the latrines (whether in mixed or in other schools), and the latrines themselves, must be separate for the two sexes, and constructed entirely apart from each other. In the case of a mixed school this rule especially affects the planning. Where passages or corridors are *unavoidably* used by both sexes, there must be complete supervision from the classrooms by sheets of clear glass.

(*b*) Each closet must be not less in the clear than 2 feet 3 inches wide nor more than 3 feet, *fully lighted and ventilated* and properly screened or supplied with a door. More than one seat is not allowed in any closet.

(*c*) The children must not be obliged to pass in front of the teacher's residence in order to reach their latrines.

(*d*) The following table shows approximately the number of closets needed :—

	For Girls.	For Boys.	For Infants.
Under 30 children . .	2	1	2
,, 50 ,, . .	3	2	3
,, 70 ,, . .	4	2	3
,, 100 ,, . .	5	3	4
,, 150 ,, . .	6	3	5
,, 200 ,, . .	7	4	6
,, 300 ,, . .	8	5	7
		Urinals in proportion.	

(*e*) Cesspits and privies should only be used where unavoidable, and should be at a distance of at least 20 feet from the school. [Building Form "A," which may be obtained on application, gives suggestions as to their construction and arrangement.] Earth or ash-closets of an approved type may be employed in rural districts, but drains for the disposal of slop and surface water are still necessary. The proximity of drinking-wells should be carefully avoided.

(*f*) Soil drains must always be laid outside the building (on a hard even bottom of concrete) in straight lines with glazed stoneware pipes, carefully jointed in cement and made absolutely water-tight. A diameter of 4 inches is sufficient unless for drains receiving the discharge of more than 10 closets. Above this number the diameter should be 6 inches. The fall should never be less than 1 in 30 for 4-inch, and 1 in

40 for 6-inch drains. An inspection opening or chamber should be provided at each change of direction so as to facilitate cleansing the drain without opening the ground. Every soil drain must be disconnected from the main sewer by a properly constructed trap placed on the line of drain between the latrines and the public sewer. This trap must be thoroughly ventilated by at least two untrapped openings; one being the 4-inch soil pipe carried up full size above the roof, and the other an inlet pipe connected with the side of the trap farthest from the public sewer. Automatic flushing tanks are desirable where trough-closets are used.

(*g*) Urinals must in all cases have a sufficient supply of water for flushing.

(*h*) Waste pipes from sinks or lavatories should be first trapped inside and then made to discharge direct through an outer wall over a trapped gulley.

14. DESKS.

14. Benches and desks, graduated according to the ages of the children, should be provided for all the scholars, and placed at right angles to the light. (See also Rules 3 (*a*) and 9.) The benches should be fitted with backs.

An allowance of 18 inches per scholar at each desk and bench will suffice (except in the case of the dual desk), and the length of each group should therefore be some multiple of 18 inches, with gangways of 18 inches between the groups *and at the walls.* A desk for one child needs no gangway next the wall. In the case of the dual desk the usual length is 3 feet 4 inches, and the gangways 1 foot 4 inches.

(*a*). The desks should be *very slightly* inclined. An angle of 15° is sufficient. The objections to the inclined desk are, that pencils, pens, etc., are constantly slipping from it, and that it cannot be conveniently used as a table. The objection to the flat desk is, that it has a tendency to make the children stoop. A raised ledge in front of a desk interferes with the arm in writing.

(*b*) No benches and desks, three rows deep, should be more than 12 feet long, nor, when four rows deep, more than 9 feet long. And no group of long desks, in a schoolroom providing for more than 60 children, should contain more than four rows of benches and desks even when the width is more than 21 feet 6 inches (Rule 2), because in proportion as the depth is increased the teacher must raise his voice to a higher pitch; and this becomes exhausting to himself, while at the same time it adds inconveniently to the general noise.

With the use of the dual desk the space between seat and desks disappears, as the children stand in the gangways.

15. SITES AND PLAYGROUNDS.

15. Every school should have an open airy playground proportioned to the size and needs of the school, and the site should, if possible, have a building frontage in proportion to its area. The minimum size of site is, in the absence of exceptional circumstances, a quarter of an acre for every 250 children. If the school is of more than one storey this area may be proportionally reduced; but the minimum unbuilt on or open space of 30 square feet per child should be preserved.

(*a*) In the case of a mixed school of large size, playgrounds should be separate for the boys and girls.

(*b*) All playgrounds should be fairly square, properly levelled, drained, inclosed, and fitted with some simple appliances. A portion should be covered, having one side against a boundary wall. A covered-way should never connect the offices with the main building. Buttresses, corners and recesses should be avoided.

(*c*) An infant school should have its playground on the same level as the school, and open to the sunshine.

16. INFANT SCHOOLS.

16. Infants should not, except in very small schools, be taught in the same room with older children, as the noise and the training of the infants disturb and injuriously affect the discipline and instruction of the other children. Access to the infants' room should not be through the older children's schoolroom.

(*a*) There must be no opening wider than an ordinary doorway between an infants' and any other schoolroom, because of the sound of the infant teaching.

(*b*) An infant school (and playground) should always be on the ground floor, and if more than 80 scholars are admitted, should have one gallery and a small group of benches and desks for the occasional use of the older infants.

(*c*) No infant gallery should hold more than 65 infants, nor in a babies' room more than 50. The back should consist of a wooden rail fixed slightly below the level of the children's shoulders. It should be well lighted from one side. The light for object lessons is as good from the right as from the left.

(*d*) The width of an infant schoolroom should be in proportion to its size, but not more than 24 feet. A covered marching-ground is desirable.

(*e*) The babies' room should always have an open fire, and be maintained at a temperature of about 65°. As a rule it should not contain more than 50 children, and should be under supervision from the schoolroom. Large schools may require two communicating rooms for babies, one fitted with low Kindergarten desks, the other providing ample floor-space for exercises.

(*f*) The accommodation of an infant school is calculated at 9 *square feet for each child*, after deducting *wasted or useless space.* Care should be taken that the numbers are conveniently seated and that space is left for marching.

(*g*) Where a Second Standard is taught in an infant school a separate classroom is necessary, and its accommodation is calculated at 10 square feet per child.

(*h*) Infant classrooms should, as a rule, not contain more than 60.

17. and 18. Give details as to Cookery Centres and Rooms for Special Instruction.

19. TEACHER'S HOUSE, etc.

19. The *Residence for the Master or Mistress* should contain a parlour, a kitchen, a scullery and three bedrooms; and the *smallest* dimensions which their Lordships can approve are:—

For the parlour	12 ft. by 12 ft.	of superficial area;	8 feet	in height to wall-plate.
,, ,, kitchen	12 ft. by 10 ft.		8 feet	
,, one of the bedrooms	12 ft. by 10 ft.		8 feet if ceiled at wall-plate; or 7 feet to wall-plate, and 9 feet to ceiling.	
,, two other bedrooms	9 ft. by 8 ft.			

(*a*) The residence must be so planned that the staircase is immediately accessible from an entrance-lobby, and from the parlour, kitchen and each bedroom, without making a passage of any room.

(*b*) Each bedroom must be on the upper storey, and must have a fireplace.

(*c*) The parlour must not open directly into the kitchen or scullery.

(*d*) There must be no internal communication between the residence and the school.

(*e*) Windows should be carried up as nearly to the ceilings as practicable.

(*f*) There must be a separate and distinct yard, with offices.

(*g*) A Caretaker's house need not be quite so large.

(*h*) All houses should be separate from and not built as part of the schoolhouse.

INDEX.

ACCIDENTS in school life, 129.
Accommodation of eye, 81.
Adaptation of eye, 80.
Adenoid growths, 47.
Afferent impulses, 9.
Age for school attendance, 22.
— in relation to eyesight, 82.
— in relation to infectious diseases, 167.
Air in schools *v.* houses, 26.
— impurities of, 215.
— index of impurity of, 217.
Artificial lighting, 210.
— ventilation, 212.
Astigmatism, 105.
Automatic movements, 7.
Average attendance, as affected by infectious diseases, 154.
BATHING and vicious habits, 51.
— in schools, 127.
Bite of dog, 132.
Blackboards, 93, 287.
Boarding schools, diet of, 123.
— — infectious diseases in, 168.
Books, type of, 94, 288.
Boyle's mica flap, 234.
Brain, grey matter, 5.
— influence of muscular exercise on, 109.
Burgerstein, tests on mental exhaustion, 36.
Burns, 134.
CARBON dioxide, estimation of, 218.
Carnelley on air of schools, etc., 26, 258.
Chicken-pox, 145.
Chorea, 42, 176.
Cisterns, 265.
Classes too large, 70.
Classrooms, 299.
Cleansing of school, 289.
Cloakrooms, 199.
Closure of schools, 157.
Clothing, amount and distribution, 124.
Code of Education Board, 295.
Conscious memory, 13.
Contusions, 135.
Convection in ventilation, 225.
— in warming, 236.
Convergence of eyes, 87.
Corporal punishment, 61.
Corridors in school, 199.
Cortex of brain, 6.
DECORATIONS, 209.
Dendrons, 4.
Desks, 96, 282, 303.
Development of nerve cells, 19.
Diet in relation to growth, 120.
Diffusion in ventilation, 229.
Diphtheria and school attendance, 28, 174.
— natural history of, 143.
— school closure for, 165.
Discipline, 60.
Disinfection of school, 292.
Dislocations, 135.
Dormitories, 118.
Drainage, 269.
Drawing, 58.
Dress, physiology of, 124.
Drowning, 130.
Dukes on school dormitories, 118.
Dustbin, 268.
EARTH-CLOSETS, 278.
Education, Board of, code, 295.
Efferent impulses, 9.
Entrances, 298.
Epileptic children, 49.
— attacks in school, 130.
Ethical education, 16.
Examinations, 63, 66.
Excessive mental exercise, 35.
Exercise, forms of, 114.
Exhaust ventilation, 257.
Exhaustion, tests for mental, 36-41.
Eye, structure of, 76.
Eyesight, 74.
— statistics of, 98.
— tests of, 97.
FAINTING, 129.

Fat, importance of, in food, 122.
Feeble-minded children, 49.
Filtration of water, 266.
Fireplaces in schools, 239.
— as ventilators, 242.
Fits in school, 130.
Floors, 202, 297.
Food and growth, 120.
Football, 135.
Foreign bodies, 131.
Foundation of school, 200.
Fractures, 134.
Furniture of school, 281.
GERMAN measles, 146.
Griesbach on mental fatigue, 40.
Ground water, 191.
Growth of boys and girls, 30.
— and food, 120.
Gymnastics and vicious habits, 51.
HÆMORRHAGE, 133.
Hand, signs of mental exhaustion, 39.
Head, signs of mental exhaustion, 40.
Headache in mental fatigue, 44.
— from eye defects, 88.
Hearing, defects of, 44, 46.
Height of children, 28.
Hodge, experiments on exhaustion, 35.
Home lessons, 55.
Hot-water pipes, 239.
— air heating, 240.
Hygiene, study of, 72.
Hypermetropia, 102.
Hysterical attacks, 130.
IMPOSITIONS, 62.
Infant schools, 304.
— — closure of, for infectious diseases, 167.
— — eye work in, 89.
— — working with small objects in, 20.
Infection, nature of, 137.
— duration of, 149.
Infectious diseases, influence of school attendance on, 27, 139.
— — natural history of, 142.
Inlets of air, 245, 253.
Inspection methods, 64, 66.
— of schools, medical, 172.
Itch, 180.
JANUSCHKE, experiments on duration of lessons, 38.
KELLER on physical fatigue in mental effort, 38.
Kemsies on mental fatigue, 39.
Kerr on artificial ventilation, 259.
— on eyesight in Bradford schools, 99.
— on seats and desks, 286.
Kotelmann on mental exhaustion, 36.
LARGE classes, evils of, 70.
Laser, experiments on mental exhaustion, 37.
Lavatories, 200.
Lessons, duration, 54.
— order of, 56.
Lice in head, 178.
Light, direction of, 206.
— supplementary, 207.
Lighting of schools, 92, 198, 205.
Long-sightedness, 102.
MAP-DRAWING, 90.
Measles, 146.
— school closure for, 165.
Mechanical ventilation, 242.
Medical inspection of schools, 172.
Memory, 9, 13.
— sub-conscious, 14.
Mental fatigue, 36.
— overstrain, 43.
Milk in relation to infectious disease, 123.
— pasteurisation of, 123.
Moisture in air, estimation of, 219, 250, 256.
Mumps, 146.
Murphy, S., on spread of infection in schools, 140.
Muscular sense, 10.
— exercise and health, 108.
Music and hygiene, 58.
Myopia, 103.
NEEDLEWORK in infant schools, 90.
"Nerve signs," 22.
— strain, 21.
— — from use of eye muscles, 87.
Nervous system, anatomy, 3.
— — physiology, 5.
Neurone, 4.
OBJECT teaching, 59.
Observation, powers of, 9.
Ophthalmia, 182.
Outlets of air, 246, 253.
Overwork, means of recognising, 45.
PEDICULOSIS, 178.

Pedley, on children's dental condition, 177.
Perflation in ventilation, 229.
Physical education, 107.
— examination of children, 176.
Physics of vision, 76.
Physiology of nervous system, 5.
— of vision, 74.
— of work, 84.
Playground, 203, 304.
Plenum ventilation, 258.
Postures in sitting and standing, 113.
Programme of school work, 52.
Psychology of vision, 75.
Punishment, 60.
Pupil teachers, 71.
QUARANTINE, duration of, 153.
RADIATION in warming, 237.
Reading, hygiene of, 57.
— in infant schools, 90.
Reasoning, powers of, 9.
Refraction, errors of, of eye, 102.
Refuse, disposal of, 268.
Respiration, effect of, 214.
Rest, 116.
Rickets in relation to diet, 122.
Ringworm, 180.
Roof, 201, 297.
Rötheln, 146.
ST. VITUS'S DANCE, 42, 176.
Sanatorium for infectious diseases, 170.
Sanitary arrangements, 268, 301.
Scabies, 180.
Scald head, 182.
Scarlet fever, 143.
Schools, closure of day, 161.
— closure of Sunday, 162.
Seats in schools, 96, 284.
Senses, education of, 10.
Sex in education, 33.
Sheringham's valve, 234.
Short-sightedness, 103.
Shuttleworth on feeble-minded children, 49.
Sikorsky, tests on mental exhaustion, 36.
Site of school, 189, 304.
Slates, 288.
Sleep, 117.
Small-pox, 145.
Soil pipe, 272.
Sore eyes, 100.
Spasm of eyes, 96.
Speech faculty, 11.
Sprains, 135.
Staircases, 300.
Steam pipes, 239.
Stimulants and vicious habits, 51.
Stings, 132.
Stoves, 244.
Stupidity, artificial, 44, 46.
Subjects, change of, 56.
Subsoil, 189.
Suffocation, 130.
Sunday schools, 162.
Swimming, 128.
TEACHER, health of, 68.
— house of, 197, 305.
Teeth of children, 177.
Temperature of air, 241, 249, 255.
Thermometer in school, 241.
Thorne, R. T., on infectivity, 144.
Tobin's tubes, 233.
Touch, impairment of, 40.
Towels for each pupil, 119.
Training, capacity for, 19.
— muscular in young children, 112.
Trough-closets, 277.
Type of books, 94.
UNDER-FEEDING, 121.
United States, medical inspection of schools in, 175.
Urinals, 275.
VENTILATION, necessity for, 212.
— natural, 223, 300.
— natural *v.* artificial, 235, 257.
Vicious habits, 51.
Vision, tests of, 97.
WALLS of school, internal surface, 93, 201.
— decoration of, 209, 297.
Warming of schools, 236, 301.
Warner, on "nerve signs," 41.
— on rickets, 122.
Water-closets, 200, 270.
— supply, 262.
Weight of children, 28.
Whooping cough, 146.
Wildershein, experiments on exhaustion, 35.
Windows of schools, 91, 203, 300.
— area of, 206.
— as ventilators, 234.
Work, physiological law of, 84.
Wounds, 132.
Writing, hygiene of, 58.
— in infant schools, 90.

APPENDIX II.

(*The following modified regulations of the Board of Education as to epidemic grants have been introduced as this book is passing through the press.*)

Instructions to Managers.

For the purpose of a claim under Article 101* of the Code, managers are no longer required to fill up a Schedule with particulars of the absence in consequence of epidemic sickness of each child in respect of whom additional attendances are claimed.

The claim is now to be made by entries in VII. (6) on page 4 of Form 9, showing for each department the total of the absences marked ○ in the attendance registers (see Section 17 of Appendix II. of the Revised Instructions).

If any claim is made, there must be filed either the notice of the Sanitary Authority, or a Medical Certificate attesting the prevalence of the infectious disease on account of which children were excluded from School.

The Board of Education will determine for each department the additional attendances to be recognised for the special grant by reducing the total of the absences marked Ⓔ in the registers, in the proportion borne by the actual average attendance to the average of the numbers on the books of the department at the end of each quarter.

The circumstances under which absence may be marked Ⓔ are detailed in Section 17 of Appendix II. of the Revised Instructions, and H.M. Inspector may require to see the authority for the marking of absence previous to the day of his visit as due to epidemic sickness.

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